

DOCUMENT RESUME

ED 148 598

SE 023 446

AUTHOR Gibbons, James P.; And Others
 TITLE Off-Campus Higher Education Engineering Instruction Using Videotape. Final Report.
 INSTITUTION Stanford Univ., Calif. Stanford Electronics Labs.
 SPONS AGENCY Office of Education (DHEW), Washington, D.C.
 BUREAU NO Technology Application Div.
 PUB DATE 4735
 CONTRACT Jun 76
 NOTE 400-75-0038
 80p.; Some pages may be marginally legible due to print quality

EDRS PRICE MF-\$0.83 HC-\$4.67 Plus Postage.
 DESCRIPTORS *College Science; *Educational Research; *Educational Television; *Engineering Education; Higher Education; Instruction; Science Education; *Television
 IDENTIFIERS *Research Reports

ABSTRACT

This document presents the final report of a project to evaluate the effectiveness of using videotape television to present graduate level engineering courses to on-campus and off-campus students. Included are the statistical analyses, review of three experiments with on-campus classes, and results of an attitudinal interview with off-campus students. Results indicate televised instruction is as good as live instruction in large lecture classes, has an advantage for students of lesser ability or marginal preparation, and is an economically attractive method for extending good teachers. (SL)

 * Documents acquired by ERIC include many informal unpublished *
 * materials not available from other sources. ERIC makes every effort *
 * to obtain the best copy available. Nevertheless, items of marginal *
 * reproducibility are often encountered and this affects the quality *
 * of the microfiche and hardcopy reproductions ERIC makes available *
 * via the ERIC Document Reproduction Service (EDRS). EDRS is not *
 * responsible for the quality of the original document. Reproductions *
 * supplied by EDRS are the best that can be made from the original. *

ED148598

STANFORD ELECTRONICS LABORATORIES

DEPARTMENT OF ELECTRICAL ENGINEERING
STANFORD UNIVERSITY · STANFORD, CA 94305



OFF-CAMPUS HIGHER EDUCATION ENGINEERING
INSTRUCTION USING VIDEOTAPE

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY.

James F. Gibbons
Kenneth S. Down
William R. Kincheloe, Jr.
Emerson Jay Lindsay

SCOPE OF INTEREST NOTICE

The ERIC Facility has assigned this document for processing to:

SE HE

In our judgement, this document is also of interest to the clearinghouses noted to the right. Indexing should reflect their special points of view.

IR

Final Report

Project No. 4735

Contract No. NIE 400-75-0038

June 1976

U.S. DEPARTMENT OF HEALTH,
EDUCATION, AND WELFARE
Office of Education
Technology Application Division

SE 023 446

Final Report

Project No. 4735

Contract No. NIE 400-75-0038

**OFF-CAMPUS HIGHER EDUCATION
ENGINEERING INSTRUCTION USING VIDEOTAPE**

**James F. Gibbons
Kenneth S. Down
William R. Kincheloe Jr.
Emerson Jay Lindsay**

**School of Engineering
Stanford University
Stanford, California 94305**

June 1976

The research reported herein was performed pursuant to a contract with the Office of Education, U.S. Department of Health, Education and Welfare. Contractors undertaking such projects under government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

**U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Office of Education
Technology Application Division**

ABSTRACT

We describe research to evaluate the effectiveness of a method for using electronics media in education which we term Tutored Video Instruction (TVI). The pre-existing Stanford Television Network and graduate engineering program with industry which made the TVI program possible is briefly described, along with a review of early successful TVI results which led to the assessment studies described here. Research conducted under this grant includes statistical analysis of past data accumulated under the TVI program, three TVI experiments with on-campus classes, and attitudinal interviews with off-campus students in industry. With due regard for limits imposed by sample sizes and limited control of experimental variables, it was concluded that TVI instruction can be at least as good as live engineering instruction in a large lecture class, has definite advantages for students of lesser ability or marginal preparation, and provides an economically attractive method for extending the effectiveness of good teachers.

To assist others who may be considering the starting of a TVI program similar to that of Stanford, the management and operation of the Stanford program are described with suggestions and recommendations for establishing such a program.

ACKNOWLEDGEMENTS

We thank J. G. Linvill for encouragement and support, as well as our many teaching colleagues and the staff of the Instructional Television Network at Stanford for their patience and cooperation. J. Lindsay and R. Latta assisted with the statistics, and a number of our colleagues made helpful criticisms and reviews of these efforts. The Technology Application Division of the Office of Education, U.S. Department of Health, Education and Welfare provided support and guidance for the statistical studies reported here.

TABLE OF CONTENTS

ABSTRACT	11
ACKNOWLEDGEMENT	111
I INTRODUCTION	1
A. Background	1
1. The Stanford Instructional Television Network	1
2. The Tutored Videotape Instruction (TVI) Method	1
B. TVI Evaluation During this Contract	2
C. TVI Program Management	3
II EARLY RESULTS IN THE STANFORD TVI PROGRAM	5
III ASSESSMENT STUDIES	7
A. Statistical Analysis of Past Data	7
1. Predictor Variables	7
2. Regression Analysis of TVI and On-Campus Students	8
B. First On-Campus TVI Experiment - EE221A	9
1. Experimental Design	9
2. The Effect of Non-Random Sampling	9
3. A General Linear Hypothesis Model	10
4. Differences Between TVI Groups	11
C. Second On-Campus TVI Experiment - EE221B	12
1. Performance Results	12
2. Interaction Data	12
3. Student Attitudes and Assessments	13
D. Third On-Campus TVI Experiment - EES201B	14
1. Experimental Design	14
2. Group Interaction Study and Observation Instrument	15
3. Performance Results	16
4. Student Attitudes Toward TVI	17
E. Interviews with Off-Campus Students in Industry	18
F. Summary	20

TABLE OF CONTENTS

IV	MANAGEMENT AND OPERATION OF THE STANFORD TVI PROGRAM	21
	A. Results with the TVI Program Continuation	21
	B. TVI Program Initiation at Stanford	22
	1. The Existing Honors Cooperative Program (HCP) . . .	23
	2. Use of the Stanford Instruction Television Facilities	23
	3. Use of Existing, Live, Unedited On-Campus Classes .	24
	4. Arrangements with the TVI Companies	25
	5. Financial Arrangements	25
	C. TVI Program Management	26
	1. TVI Students in Industry	26
	2. The TVI Tutor	27
	3. The Course Instructor, Secretary, Teaching Assistant and Grader	29
	4. The Stanford Instructional Television Network . . .	31
	5. TVI and the University Administration	32
	6. TVI Program Management in Industry	34
	7. The TVI Campus Coordinator	35
	8. TVI Records	37
	9. Program Planning for TVI Students	38
	10. TVI Problem Areas	39
V	ESTABLISHING A TVI PROGRAM	42
	A. Studio Classroom and Recording Facilities	42
	B. Operation and Management of a TVI Program	44
	1. Operation Personnel and Costs at the Originating Organization	44
	2. Academic and Accreditation Arrangements	45
	3. Arrangements at the TVI Student Organization	45
VI	CONCLUSIONS AND RECOMMENDATIONS	46
	A. Conclusions from this Study	46
	B. Recommendations	48
	1. Factors that Contribute to TVI Effectiveness	48
	2. Extensions of the TVI Method	49
	REFERENCES	51
	APPENDIX A: Observation Instrument for TVI Classroom Interaction.	A-1

ILLUSTRATIONS

2.1	Comparative GPA - 1973-74	5a
2.2	Comparative GPA - 1973-74	5b
2.3	GPA Variation with TVI 1972-74	6a
2.4	Results of Tutored Videotape Instruction Experiment	6b
3.1	Performance vs Ability (EE221A)	10a
3.2	Student Reactions to TVI (EE221A)	11a
3.3	Performance vs Ability (EE221B)	12a
3.4	Performance vs Ability (EES201B)	16a
3.5	Correlations of Ability, Performance, and Interaction (EES201B)	17a
3.6	Campus Student Attitudes toward TVI (EES201B) . .	17b

TABLES

5.1	ITV Classroom Capital Cost	44a
5.2	Amortized Cost Per Lecture of TVI Facilities . .	44b

I. INTRODUCTION

A. BACKGROUND

1. The Stanford Instructional Television Network (SITN)

Since 1953 the Stanford School of Engineering has had a cooperative program with local industry in which employed engineers may take part-time courses at Stanford leading to a graduate degree in Engineering, the so-called HCP (Honors Cooperative Program). Initially students attended classes on campus; however, the difficulties of transportation, lost time and awkward scheduling led in 1969 to the installation of a four-channel ITFS (Instructional Television Fixed Service) network with audio talkback to the campus classroom so that industrial students may attend and participate in classes at any of approximately 135 classrooms in nearly 50 organizations throughout the San Francisco Bay area (1).

Not only has the Stanford ITV system been well received and both economically and educationally successful, it has permitted two significant developments not previously available from Stanford because of on-campus classroom limitations: (1) It has permitted an essentially unlimited increase in course auditing by practicing professionals who may not be interested in a degree program (since they do not participate actively in the class and therefore pose no additional burden on the instructor or registered students), and (2) made possible the so-called NRO (Non-Registered Option) program whereby off-campus students who wish to do graded course work but either do not wish to be in a formal degree program or who might not otherwise be admitted to Stanford because of inadequate prior records may take courses by television and receive a grade relative to the regular matriculated students. Adequate NRO performance may then be used as a basis for admission to graduate standing as a degree candidate; this possibility has been utilized by a number of otherwise marginal (or "late-blooming") students in the Stanford graduate program.

2. The Tutored Videotape Instruction (TVI) Program

The need and desire for continuing education by engineers at companies located outside the television reception range of the Stanford ITV transmitter has led naturally to the use of videotape of live classes, an extension easily made possible by the existing facilities. This posed no problems for auditing but did not satisfy the desire for (and motivational advantage of) accredited degree programs. This further led in 1973 to the initiation of a controlled experiment in the use of videotape together with a paraprofessional tutor for off-campus graduate engineering instruction for which academic credit was given, a method referred to here as Tutored Videotape Instruction, or TVI. This appeared to have the potential

for removing geography as a limitation and for making possible a new dimension in continuing education for employed engineers and scientists in industry.

The first year of the TVI experiment provided data which suggested that this mode of instruction could provide a quality of education that was not only equivalent to but in some cases was superior to that of live television and even the standard lecture classroom. Based on these results University permission was given for the granting of academic credit leading to a graduate degree, with the understanding that the program would be carefully monitored. Some of the early results have been described elsewhere (2,3,4) and are summarized in Section II of this report.

B. TVI EVALUATION DURING THIS CONTRACT

The Stanford approach of Tutored Videotape Instruction (TVI) combines four elements: (1) unedited videotapes of on-campus lectures, (2) a small group of interested students, (3) a tutor who is familiar with the subject and who watches the videotape with the students, and (4) an interactive mode of delivery whereby the tape is stopped as needed during playback in order to permit questions, discussion, and introduction of related material. Little discussion has been found in the literature assessing this approach. While a number of studies have been made of the effectiveness of television in instruction, many of which are cited in Chu and Schramm's *LEARNING FROM TELEVISION* (5), a singular gap in the fabric of those studies is the lack of an investigation into mixing televised instruction with live tutoring. Chu and Schramm noted:

"The effectiveness of television has now been demonstrated in well over 100 experiments, and several hundred separate comparisons, performed in many parts of the world, in developing as well as industrialized countries, at every level from pre-school through adult education, and with a great variety of subject matter and method." (p.1)

They also concluded:

"The lack of opportunity for students to raise questions and participate in free discussion would seem to reduce the effectiveness of learning from instructional television, particularly if the students are fairly advanced or the material is relatively complicated." (p.19)

An additional observation was made that while discussion before and after television presentations assisted students in their learning, Chu and Schramm cited no cases matching the particular attributes of the TVI approach discussed here, i.e. (1) videotapes of live, on-campus presentations, (2) small interested groups, (3) tutors to interact before, during, and after the presentation, and (4) stopping the tape during the presentation for group discussion.

A check of the ERIC system revealed no other studies similar to the Stanford approach either.

In order to assess the preliminary favorable indications of the effectiveness of the TVI method, therefore, the Technology Application Division of the National Institute of Education has supported the work discussed in this report. Several studies and experiments have been performed:

1. A statistical analysis of accumulated data on TVI student performance was made to assess the predictive value of such parameters as undergraduate grade point average (GPA), Graduate Record Examination (GRE) scores, etc. as well as to see whether a statistically significant difference was found in performance of comparable on-campus and TVI students.
2. An on-campus TVI experiment was conducted for two successive quarters in which small TVI groups were formed out of a large live lecture class in order to permit observation and comparison of student performance in the TVI groups using the large lecture class as a control.
3. A second on-campus TVI experiment was conducted in the following manner: the second quarter of a continuing class was given lectures by videotape with no opportunity for stopping the tape or discussing the material during the lecture. From the large group of students, most of whom had taken the previous quarter from a live instructor, two small TVI groups were formed in a manner which was intended to permit assessment of TVI effectiveness for students of both high and low ability. An observation instrument was designed and observers were present in the TVI groups to record interactions.
4. Interviews were conducted with TVI students in several industrial locations in order to assess student and tutor attitudes as well as to examine the nature of the educational "climate" in different locations and its effect on the TVI program.

A description of these studies and the results obtained is given in Section III and References 8 through 10.

C. TVI PROGRAM MANAGEMENT

During the three years that the Stanford TVI program has been in operation the number of students and participating companies has continued to grow. Many things have been learned about the academic and administrative problems and considerations of the program. In order to share insights gained and to assist others who may be contemplating such a program two further sections are included in

this report. Section IV describes the functioning of the Stanford program with emphasis on the management and liaison between the remote TVI students and the Stanford on-campus academic program. Suggestions for establishing a TVI program are given in Sec. V, including facilities required and estimated costs. Conclusions and recommendations are given in Section VI.

II. EARLY RESULTS IN THE STANFORD TVI PROGRAM

The Stanford TVI experiment was begun as a result of a request by a local company which wished to establish a plant at a distant location but also to retain the opportunity for a graduate engineering degree program with Stanford. It involved the use of videotapes of live classroom lectures which were shown at the remote plant to a small group of students who were assisted by a local tutor provided by the company. The TVI groups were encouraged to stop the tape for discussion of key issues. The TVI students were given the same assignments and examinations as and were graded in comparison with the on-campus classroom students, and careful records were maintained of their performance.

Initial data gathered on the TVI project at Stanford suggested that not only is it a cost-effective way of providing continuing education, but it can in some cases be more educationally effective than live television or even classroom instruction. During the 1973-74 school year results indicated that academic performance of the off-campus TVI students was at least equivalent to that of on-campus students. Figure 2.1 compares performance of several categories of students in the same courses; a total of 302 on-campus students had a grade-point average (GPA) of 3.38 out of a possible 4.0, providing a norm for comparison. The students watching live classes by television with direct audio talkback capability had a GPA of 3.19, still quite acceptable but significantly below the on-campus students. The limited sample of TVI students achieved an astonishing 3.57 GPA, exceeding not only those students using live television but almost 5% above the on-campus students! This result is made more remarkable by the fact that several of the TVI students had marginal academic qualifications that would have made their admission to the Stanford graduate program questionable or subject to probation.

Figure 2.1 also shows a further breakdown of the off-campus student performance by comparing performance of the regularly admitted students with those exercising the Non-Registered Option (NRO). In the case of live television, the NRO (non-matriculated) students did significantly better than the admitted students, possibly because of the higher motivation of their probationary status. There was less difference between the already high performance of the TVI admitted and NRO students.

A different comparison of the data is shown in Fig. 2.2. In this case a grade performance is compared between the on-campus students, the live television students with audio talkback, and the videotape students with and without tutors. Here the data suggest that live television is somewhat less effective than live instruction, videotape courses without tutors less effective still (although the data for

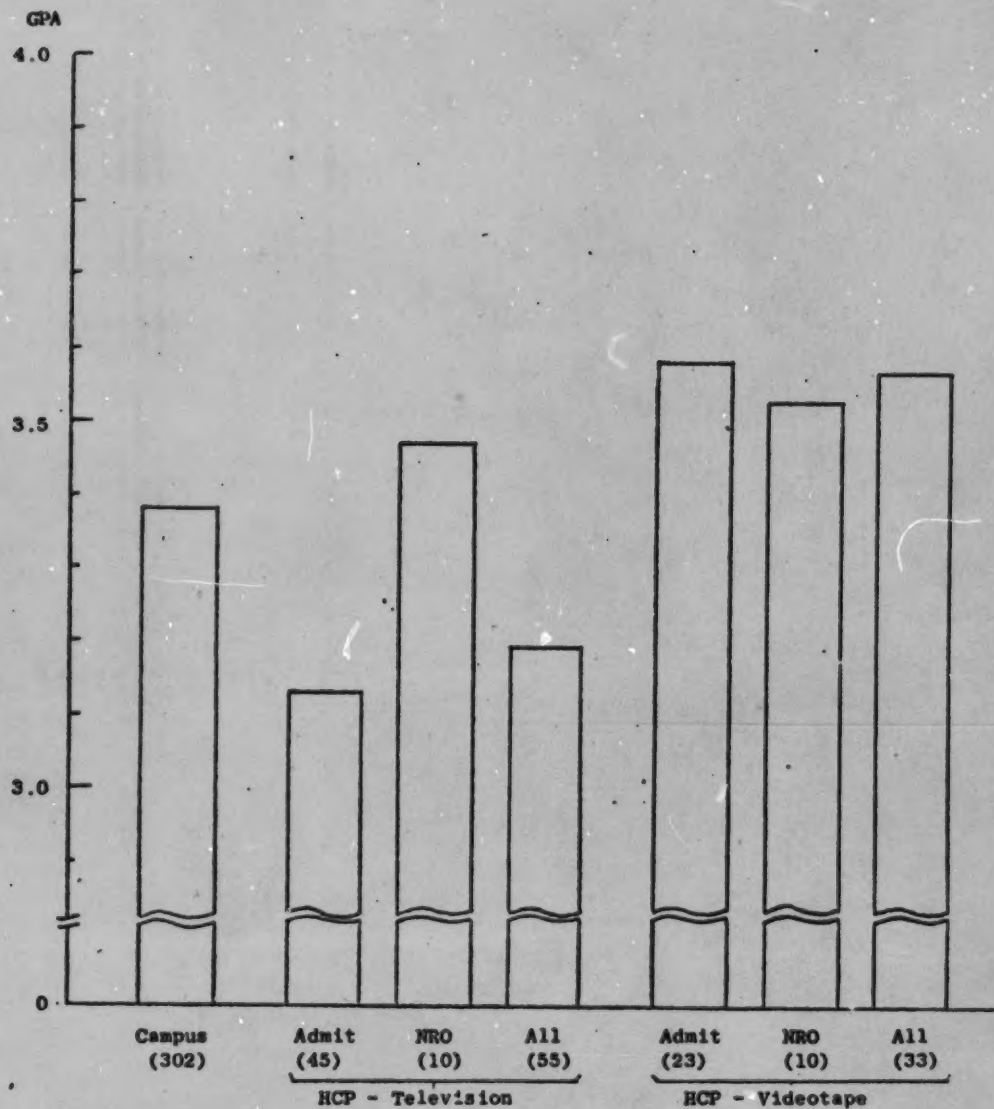


Fig. 2.1 - Comparative campus, television and videotape grade point averages. (Autumn, Winter quarters 1973-74.)

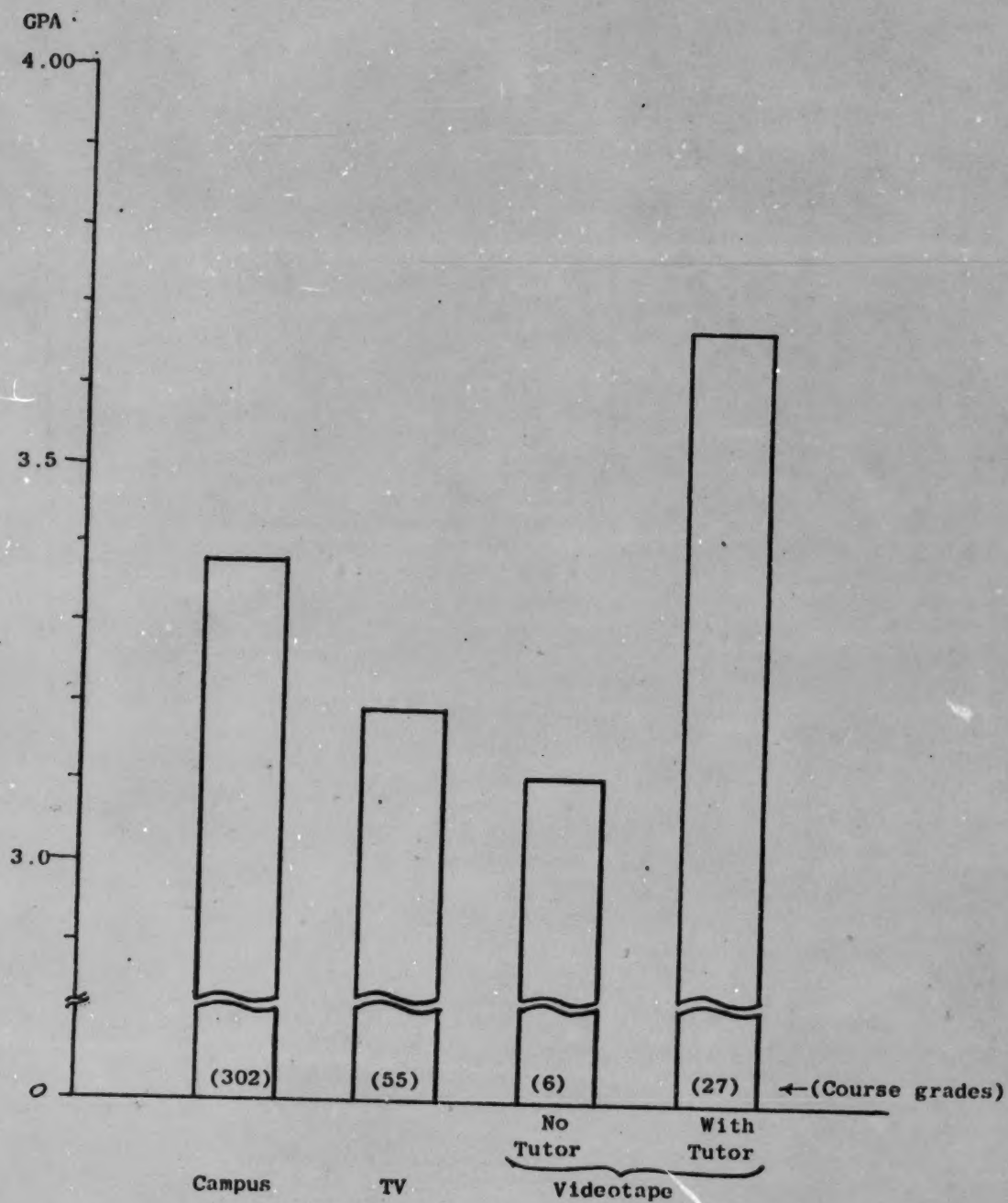


Figure 2.2 - Comparative campus, television, tutored and non-tutored videotape course grades. (Autumn, Winter quarters 1973-74.)

this was very limited), but that provision of tutors provides a striking improvement in student performance.

Another method of assessing the effect of the TVI mode is shown in Fig. 2.3. Here the quarter-by-quarter GPA's of several TVI students for whom pre-TVI televised course performance data were available are shown in chronological sequence. The trends shown in Fig. 2.3 are subject to large variations because of performance in a single class, since each plotted point represents at most two courses per quarter. Even though the sample is limited, however, a definite improving trend is evident for most of the students after changing to TVI.

A final method of assessing the data is shown in Fig. 2.4. Here a statistical procedure based on admissions qualifications was used to estimate how well a student would be expected to perform on the Stanford campus and this was then compared to the actual performance. Students lying above the line labeled PREDICTOR are performing better than expected. From the data it is seen that all of the TVI students performed better than they would be expected to perform on the Stanford campus, many of them by a substantial margin.

From this limited sample it thus appeared that the TVI method has important possibilities for the provision of continuing education for employed engineers that is both educationally significant and cost-effective, and suggested that statistical evaluation of the program was appropriate.

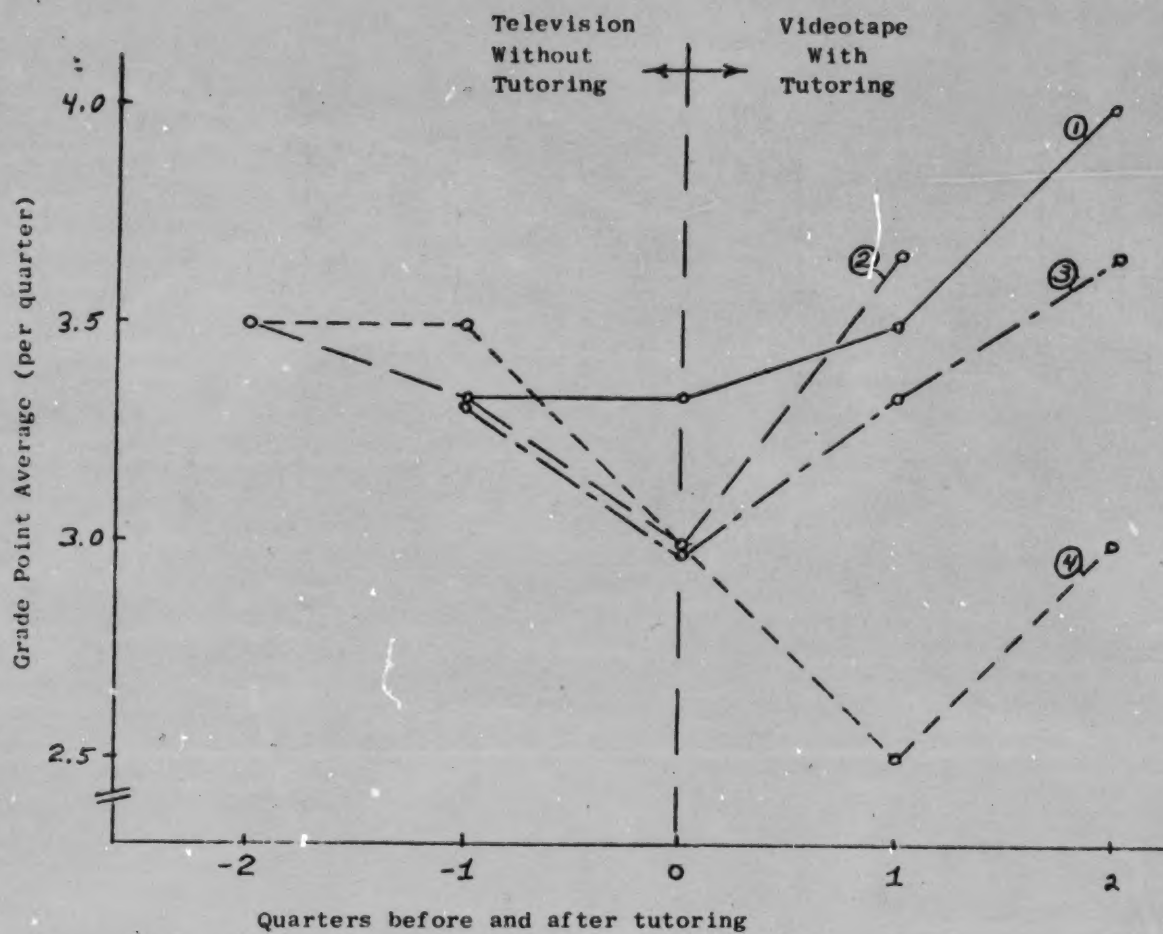


Figure 2.3 - Variation of GPA of several students changing from televised to videotape instruction.

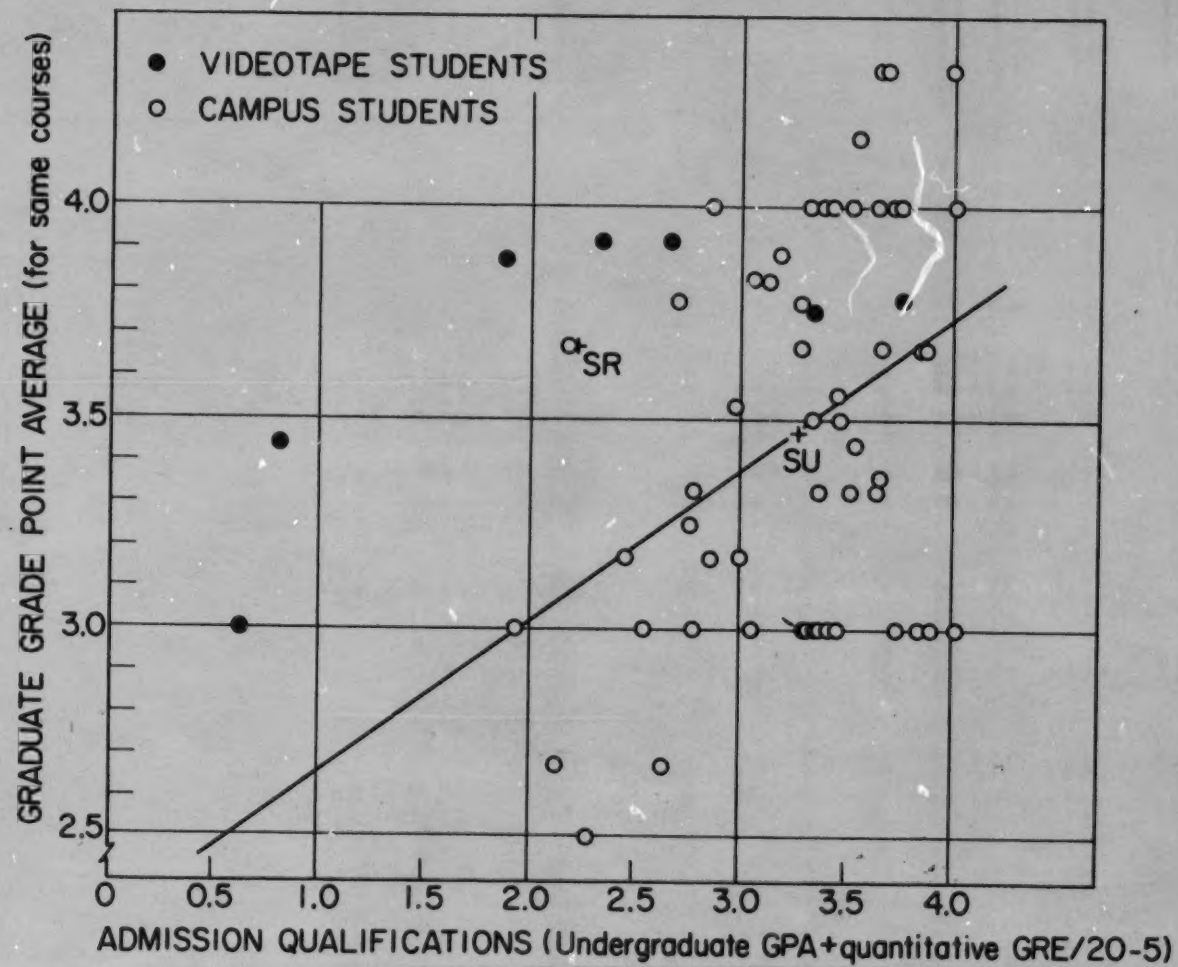


Fig. 2.4 - RESULTS OF TUTORED VIDEOTAPE INSTRUCTION EXPERIMENT (October 1973 - March 1974)

III. ASSESSMENT STUDIES

The preliminary analysis discussed in Sec. II raised several questions about the effects of nonrandom data, proper use and sophistication of statistical methodologies, and degree to which different groups of students were using the program as originally anticipated. A number of studies and experiments were formulated during the year of this contract to further examine these questions and will be summarized in this section. More complete details are given in the quarterly progress reports (References 8, 9, 10).

A. STATISTICAL ANALYSIS OF PAST DATA

The original evaluation was based on limited data and an ad hoc regression. The first objective was to update the evaluation by including data that had been gathered since March 1974 and to use more adequate statistical procedures.

1. Predictor Variables

Predictor variables used in the original study were "corrected" undergraduate grade point averages (UCGPA) and the quantitative score of the graduate record examination. (The correction includes a factor derived from the history of the performance of students from the same undergraduate institution in a graduate engineering program at Stanford.) Most of the off-campus graduate engineering students are in the Honors Cooperative Program and not required to take the GRE examination for admission to Stanford. Because of difficulty in obtaining GRE scores, a regression analysis was used to determine the GRE predictive capability; if the GRE has little predictive power then it should not be used because of the cost in obtaining scores. The study was based on a random sample of 100 electrical engineering students that graduated with a Masters Degree from Stanford in 1972 and 1973. The sample did not include any foreign students or students without GRE scores, such as many HCP students.

Results of the regression analysis are shown in Fig. 2.1 of Reference 8 which shows correlations between MS degree grade point average (MSGPA), GRE verbal (GREV), GRE quantitative (GREQ), and UCGPA. As indicated by the highest correlation with with MSGPA, the best single predictor of MSGPA is

$$\text{MSGPA} = 1.748 + .5111(\text{UCGPA}) \quad 3.1$$

with a standard error of estimate of .252. As shown in Fig. 2.1 of Appendix A, UGPA is the second best and GREV the worst single predictors. Of particular interest is the low predictive value of GREQ, accounting for only 11% of the variance. GREQ and UCGPA

together as predictors account for 38% of the variance; the associated regression equation is

$$\text{MSGPA} = 1.406 + .465(\text{UCGPA}) + .0057(\text{GREQ}) \quad 3.2$$

with a standard error of estimate of .2465. Since including the GREQ with UCGPA as predictors only increases the percentage of variance for which we can account from 35% to 38%, we conclude that the value of including GREQ as a predictor is not worth the effort of obtaining and including it in the analysis.

2. Regression Analysis of TVI and On-Campus Students

The preliminary regression analysis discussed in Sec. II was limited both by the small size of the sample and the dissimilar academic programs of the students included. To form a comparable group to the TVI students for whom data was available, Stanford students were selected from the Electronics and Devices option of the Electrical Engineering Department for comparison. Details of the analysis are given in Reference 8.

Essentially, the comparison between the TVI and on-campus students in determining MSGPA using UCGPA as a covariate showed no significant difference using a general linear hypothesis model. For the size of the data sample it was not possible to reject a hypothesis of equal intercept and parallel slopes.

The discrepancy between these results and those shown in Fig. 2.4 may be due to the fact that Fig. 2.4 was based only on initial courses taken by the first group of TVI students. The courses were within the Electronic Devices and Circuits option and because of their related work experience most of the TVI students were well prepared in this particular area before taking the Stanford courses. A second possible effect may be related to diminishing tutor interest and involvement; high initial tutor interest decreased because of lack of recognition for their efforts as well as because of a lack of perceived need for their assistance since in these courses the TVI students were sufficiently well prepared by their work experience so that the tutor role was less important. Possibly because of these factors the perception of the importance of the tutor role was minimized, affecting student performance in other courses where the assistance of a tutor was more necessary.

Caution should be used in drawing inferences from these results. Nonrandom data, non-comparable groups, and lack of understanding of how the TVI students were using the method made it difficult to draw well-founded conclusions at this point in the evaluation. It can be said, however, that data obtained to this point suggested that the TVI method seemed to be at least as good as in-class teaching for the courses used in the study.

B. FIRST ON-CAMPUS TVI EXPERIMENT - EE221A

Difficulties in analyzing and drawing sound inferences from the data with off-campus TVI students led to the design and implementation of an on-campus TVI experiment where the backgrounds of the students were more comparable. In the winter quarter of 1975 an unusually large enrollment in EE221A, a popular graduate circuit analysis course, offered an opportunity for a comparative experiment. Enrolled in the on-campus class with the instructor were 89 students, plus 11 HCP and 9 NRO industrial students receiving the class live by television and 7 TVI students at two separate remote companies, 3 in Santa Rosa and 4 in San Diego, California. In addition to reducing the rather excessive number in the originating classroom, this situation offered an interesting possibility for comparisons between the various modes of instruction.

Eighteen students volunteered to leave the regular live class with the instructor to be in small TVI groups with graduate student tutors. Since the course was taught in a television classroom for broadcast to HCP students via the Instructional Television Network, it was a simple matter to videotape the regular classroom lecture for later showing to the TVI groups. Details of this experiment are given in Reference 8.

1. Experimental Design

Three TVI groups were formed; two of the groups with one tutor were deliberately made unequal in size, consisting of twelve students in one group and six in the other, in order to examine the effect of group size. The second tutor had a group of six students. The tutors were instructed to stop the tape when a student had a question or when the tutor felt it desirable to emphasize a point. They were also encouraged to promote discussion, show a personal interest in each student, and to discuss homework problems. The scheduling of the TVI groups was arranged as much as possible to allow more time for the playback of the tape than the normal class duration in order to permit time for group interaction and discussion.

A general linear hypothesis model was used to compare performance between in-class and TVI students. Most students were graduate students in electrical engineering; because of problems in assessing academic backgrounds and possible influence of language problems foreign students were not included in the analysis. Because of low sample sizes most of the analysis combined the TVI groups into one set of data.

2. The Effect of Nonrandom Sampling

A first objective was to assess the effect of nonrandom sampling (students volunteering) by comparing pretreatment variables between groups. Cumulative Stanford graduate grade point average (CGPA) and

UCGPA were examined. Use of UCGPA was of interest as compared to other variables because of the ease of obtaining this data. There was also an interest in being able to make decisions about entering students such as which method of instruction would be most effective.

Details of the analysis are given in Reference 8, Sec. 3. Points of interest include the following:

- a. For both groups the CGPA extends over a lower range than the UCGPA.
- b. The reduction of variance from UCGPA to CGPA is larger for the TVI group.
- c. The scatter of UCGPA vs CGPA is more concentrated for the TVI group and completely within that of the in-class group. Correlation of UCGPA with CGPA is 0.62 for the TVI group and 0.477 for the in-class group.
- d. The mean of CGPA is lower than the mean of UCGPA for the in-class group but about the same for the TVI groups.

These points seem to suggest that the TVI and in-class groups were drawn from the same population; this is especially true of (c) which says that the scatters cover approximately the same range of values on both axes. Point (d) could suggest that the TVI group is more motivated; however, this could be a ceiling effect. The TVI group seems to be more homogeneous, shown especially by (c). From these data it seems reasonable to make comparisons between the performance of the two groups.

3. A General Linear Hypothesis Model.

The data was first analyzed using a general linear hypothesis model of the form

$$Y_{ni} = A_i + B_i Z_{ni} + E_{ni} \quad 3.3$$

where Y_{ni} is the total score and Z_{ni} the UCGPA for the n th student in the i th group. As shown in Ref. 8, Sec. 3, the slopes of the regression lines are significantly different. The error sum of squares is reduced 15% by including UCGPA in the model as a covariate. Students with a lower UCGPA (below 3.3) were compared using the model

$$Y_{ni} = A_i + B Z_{ni} + E_{ni} \quad 3.4$$

and it was found that the groups were significantly different. In this case the covariate had no effect. These results are illustrated in Fig. 3.1, which shows the regression lines for the class and the TVI groups plotted on a scatter diagram of class performance vs UCGPA.

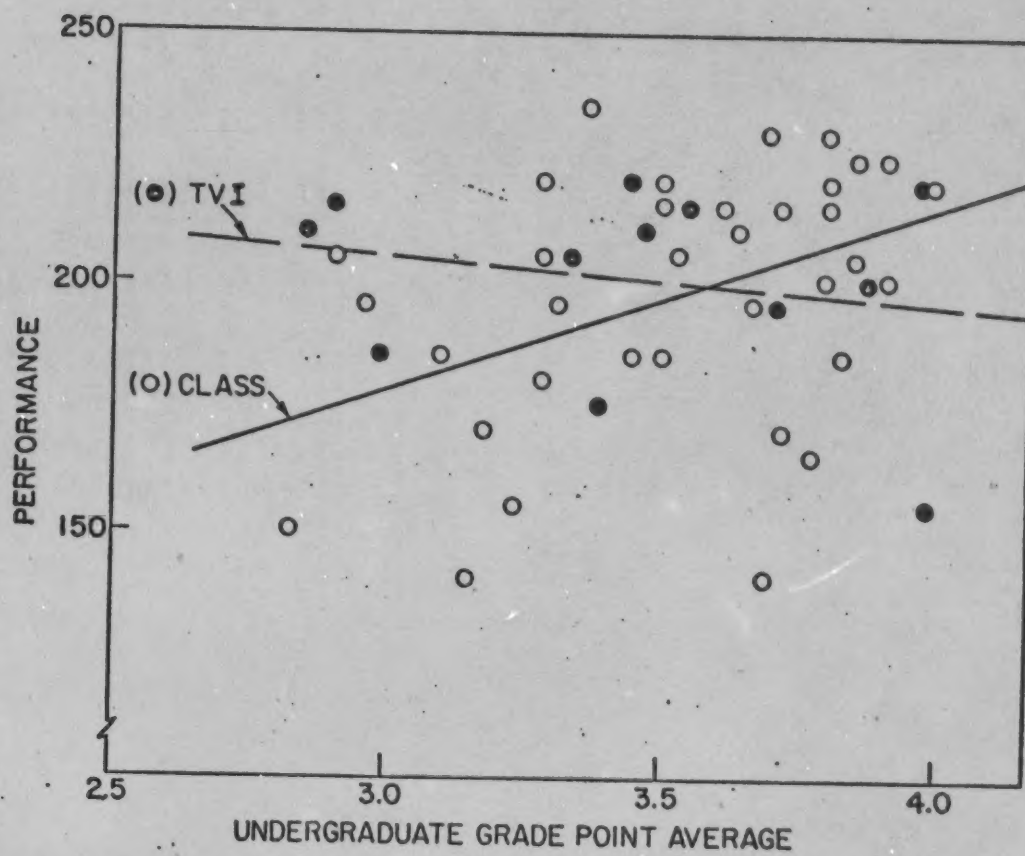


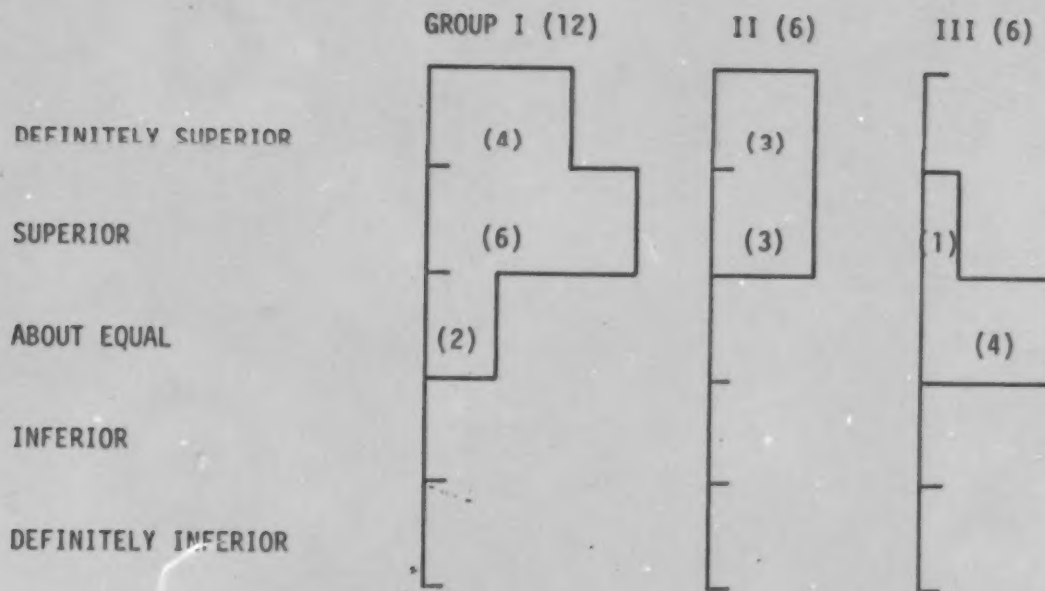
FIG. 3.1 - CLASSROOM AND TUTORED VIDEOTAPE INSTRUCTION STUDENT PERFORMANCE
(EE 221A - Winter 1975)

At the outset it was thought that better controls in this experiment would permit more sophisticated analysis of the TVI comparative educational effectiveness. It was found, however, that for a variety of possible reasons (small sample size, variation in tutor effectiveness, use of volunteers in the TVI groups, etc.) significant overall improved educational effectiveness could not be shown with high statistical reliability. However, as illustrated in Fig. 3.1, the data strongly support the hypothesis that the TVI method is at least as good as live instruction for all of the TVI students. Furthermore, for students of lower admissions qualifications the TVI method of teaching was found to be significantly more effective than in-class teaching. In fact, the regression line for TVI students in Fig. 3.1 suggests that the course performance is essentially independent of the standard measures of academic ability. This finding, which agrees with the TVI results obtained with the off-campus industrial students, becomes even more important in view of the fact that the "lower ability" group in this study had undergraduate GPA's of 3.0 to 3.3, a relatively high range. It thus seems reasonable that students of "lower ability" may profit more from the TVI method of teaching, though this is to be expected to some degree because there is less room for improvement among students of "high ability".

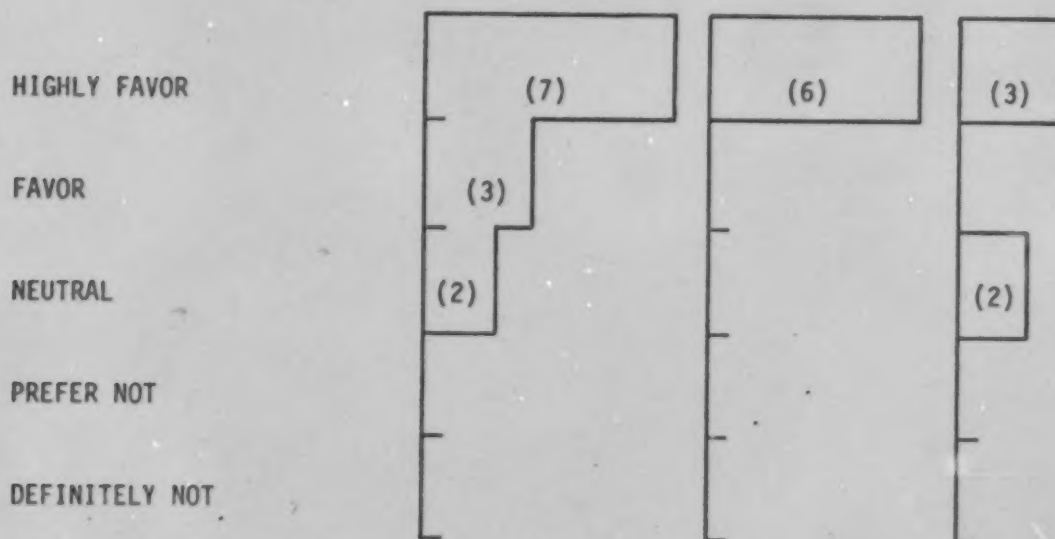
4. Differences between TVI groups

The different personalities and teaching styles of the two tutors made some comparison possible to assess the effect of these factors on student performance and attitudes. Both tutors were chosen from a set of students who had performed well in the course previously, both were very interested in the subject and both were interested in teaching as a career. However, where the tutor who was assigned the two TVI groups of 12 (group I) and 6 (group II) students had a manner which tended to encourage questions and group interaction, the second tutor with group III (6 students) was not as effective in this respect.

Student opinions of the TVI format were collected at the end of the quarter and showed a generally enthusiastic response to the method. Some characteristic features of their responses are shown in Fig. 3.2, from which some general effects of tutoring technique and group size can be seen. With respect to group size, a comparison of groups I and II with the same tutor suggest that the smaller group was generally more enthusiastic about the TVI experience than the larger group. This same general result has been repeated in our industrial TVI groups, and a consideration of all of our present data leads us to the tentative conclusion that the method works best when the group size is between 3 and 10. Figure 3.2 also shows that the students in TVI groups with the tutor who encouraged questions and interaction generally felt more favorable about the TVI experience than those in group III with the tutor who tended to be more inhibiting of group interaction.



A. RATING OF TVI EDUCATIONAL EXPERIENCE COMPARED TO LARGE LIVE CLASS



B. FEELINGS ABOUT TAKING ANOTHER COURSE IN THIS MANNER

FIG. 3.2 - STUDENT REACTIONS TO TUTORED VIDEOTAPE INSTRUCTION ON CAMPUS
(EE 221A - Winter 1975)

C. SECOND ON-CAMPUS TVI EXPERIMENT - EE221B

In the quarter following the TVI experiment in EE221A described above a similar experiment was continued in the second quarter of the course sequence in EE221B. Because the class was smaller only two TVI groups were formed; one group of eleven students met with the more successful TVI tutor from EE221A, and a second tutor met with a smaller group of five students. The live class with the instructor had 58 students, some of whom watched the class in an adjacent overflow room equipped with TV monitors and microphones for asking questions. In addition there were 13 industrial students participating in the class by live TV and audio talkback, and 9 TVI students in two separate industrial locations. Details are given in Reference 9.

1. Performance results

With few exceptions the students in EE221A and EE221B were the same and thus the analysis of EE221B was not independent of that of EE221A discussed above. As in EE221A the results as summarized in Reference 9 suggest no significant difference in the performance of the TVI and in-class students, although again, as shown in the scatter diagram of Fig. 3.3, the pattern suggests that TVI may be better for "low ability" students although the difference was not significant and the scatter plot of class performance vs CGPA shows less difference between the two groups. Because of small sample size and large variability the power of the experiment was low and it was difficult to detect differences.

2. Interaction Data

In an attempt to gather more meaningful data about classroom interaction a form was prepared (shown in Fig. 4 of Reference 9) for use by the TVI tutors. Essentially the tutors were requested to note the durations of the recorded lecture and the TVI session, as well as the source and nature of questions both in the recorded lecture and the TVI group session.

The results, while interesting, were not felt to be complete because it proved difficult for the tutors to remember to always note each interaction in their concentration on the subject matter and their students, as shown by the different numbers of in-class questions recorded by the two tutors. Probably the number of such questions was at least as high as the highest estimate from either tutor. Low reliability does not obscure the fact that few questions were asked and that on the average TVI sessions were only 5-15 minutes longer than the taped class. It was also found that a few students asked most of the questions and that these students performed relatively poorly in the class, although this does not indicate that the additional discussion generated by these questions was not of substantial benefit to the more nonverbal (and perhaps weaker) students in the TVI groups. Even 4-5 additional questions in addition to class questions on the videotape could affect learning

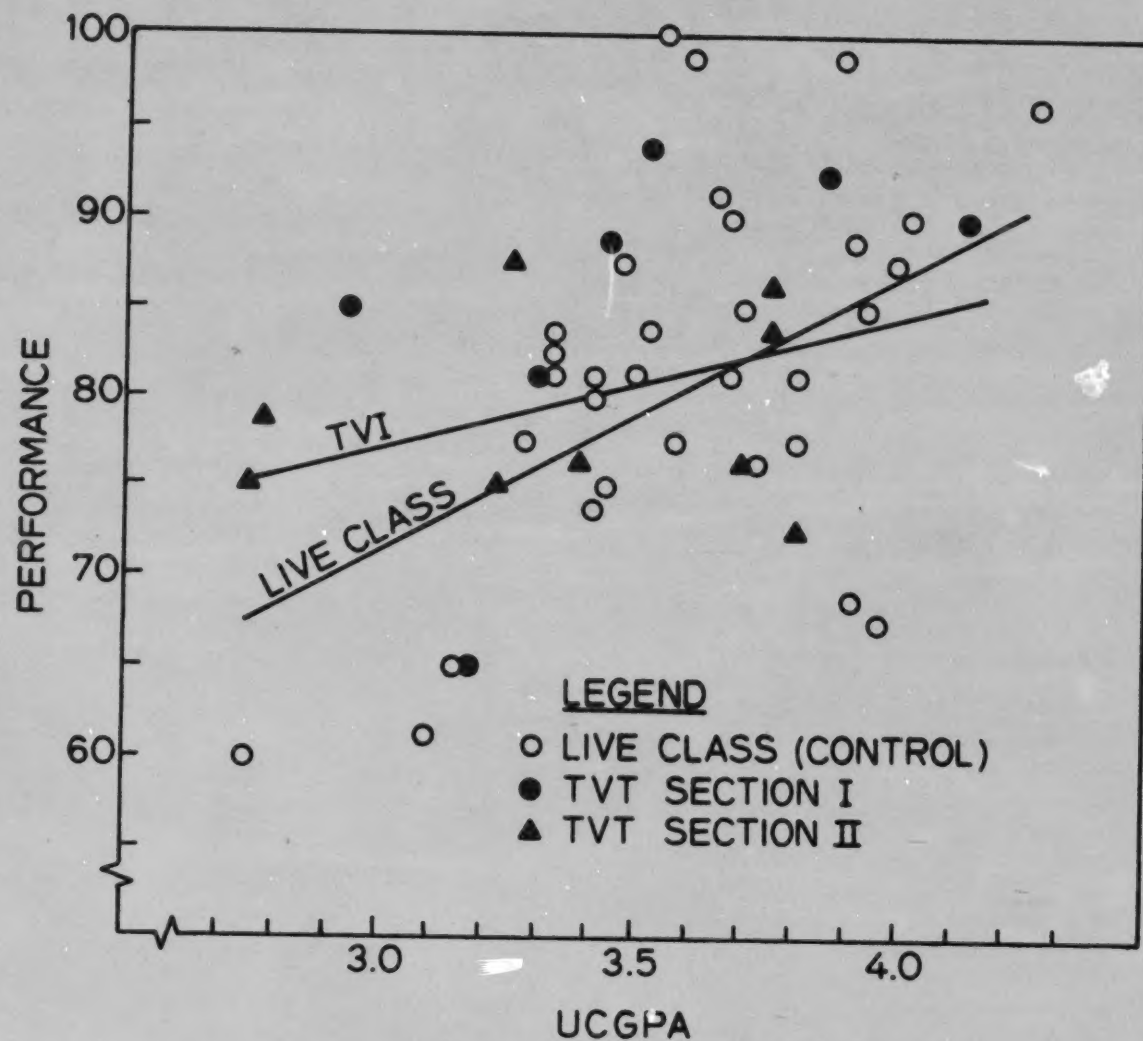


Figure 3.3 - STUDENT PERFORMANCE VS UNDERGRADUATE
CORRECTED GPA (UCGPA) - EE221B

substantially. One possible reason for the lack of questions could be the fact that the instructor for this class has a particularly clear and methodical classroom technique, so that the need for questions is not felt as much by most of the students.

3. Student Attitudes and Assessments

Questionnaires and interviews were used to determine why students volunteered for TVI instruction, student attitudes toward the TVI program, and student assessment of the qualifications of good TVI tutors. Detailed results are given in Fig. 8 of Reference 9.

In summary, as indicated by the interviews students volunteered for TVI groups for the following reasons:

- a. Lack of self confidence.
- b. Reputation of tutor.
- c. They felt they would learn more from TVI sessions.
- d. Pressures of the large classroom situation:
 - i. Time constraint on how many questions per student can be answered by the professor.
 - ii. Impersonality.
 - iii. Fear of showing ignorance.
- e. Accessibility of tutor.
- f. Increased interaction with other students - seeing other students points of view.

The most important qualifications of a good tutor were seen to be:

- a. Knowledge of the material.
- b. Sensitivity to "difficult to grasp" points in the material.
- c. Ability to set the "mood" of the class so that students feel at ease in asking questions.

The questionnaire results indicate that many in-class students feel uncomfortable in asking questions, few students ask questions, and much is learned from questions by other students. Students hesitate to ask questions in a large class because:

- a. Fear of showing ignorance.
- b. Desire to attempt answer by self.
- c. Questions are ultimately answered by the instructor anyway.
- d. Too many questions makes the class too long.

It is interesting to note that 67% of the students in the large class indicated that there were times when they wanted to ask a question and didn't, while in the TVI groups this was reduced to 46% (still a surprisingly large number if the TVI group is working well). The data further showed that the students on the average seemed to be ambivalent about studying alone or in small groups.

A significant result from the two sequential on-campus TVI experiments described above comes not from professed attitudes but from the decision of TVI students in the first experiment (EE221A) to repeat the TVI experience in the following class (EE221B). Of the 16 TVI students in EE221B, 12 had been in TVI groups in EE221A, suggesting that they perceived the TVI experience to have greater value to them than being in the large class with the instructor. The decision not to repeat the TVI experience could have been due in part to scheduling difficulties, since the TVI groups were given at a different hour than the regular class, but the comparison of TVI groups as to which students choose to repeat the experience is revealing; of those students who enrolled in both EE221A and EE221B 50% of TVI group I, 80% of TVI group II, and none of TVI group III in EE221A elected to be in TVI groups in EE221B the following quarter. Since groups I and II both experienced the same tutor who was clearly the more successful in stimulating group questions and discussion, but with group II having only 6 students where group I had 12, the importance of both the tutor effectiveness and small group size to the students is strongly suggested.

D. THIRD ON-CAMPUS TVI EXPERIMENT - EES201B

Despite the interesting results obtained in the experiments and analyses described above, it was felt that there was a need for a study of the TVI method with a better comparison between TVI and videotapes shown to a conventional class without tutoring, more control over student ability levels in the study, and more detailed data regarding student interactions in the TVI groups, if this could be accomplished without interfering with programs or manipulating students in some undesirable way.

An opportunity for such an experiment arose during the winter quarter of 1976 when the regular instructor of a popular graduate course in Engineering Economic Systems, EES201B, was to be absent from the campus and in the absence of a suitable replacement the course was to be offered to the regular on-campus students by videotape of the lectures from the previous year. Details of this experiment are given in Reference 10.

1. Experimental Design

Most of the students in EES201B had just completed EES201A, the prerequisite course immediately preceding EES201A which had been taught by the same instructor. In addition to the previously used measures of entering ability such as UGPA and GREQ, performance in performance in EES201A was available. As discussed in Reference 10, however, in this case UGPA and GREQ were of little value as additional ability measures; performance in the prior course accounted for 43.8% of the variance of that in EES201B and no other variables in combination would account for more than 44.1 percent.

Two TVI groups of 8 students each were formed by randomly sampling from the top and bottom 16 students who had taken EES201A and who had indicated a willingness to be a member of a TVI group (which included almost all of the class after the nature of the TVI groups had been explained at the beginning of the quarter). Both TVI groups were led by a tutor whose role was to answer questions and promote discussion, e.g. by pointing out additional ways of looking at the material and helping students feel at ease in asking questions. The tutors were graduate student teaching assistants in the Engineering Economics Systems Department who were knowledgeable with the subject matter of the course. During the quarter 3 TVI students dropped the course leaving 6 students in the high TVI group and 7 in the low. In each TVI group was a observer trained to use an observation instrument developed for this experiment to aid in analyzing TVI group interaction.

The control group, consisting of those 17 students in the regular class who had taken EES201A and who were not foreign students (since the preparation and performance of the latter were less predictable), viewed the videotape in a regular classroom with an instructor present with no opportunity to stop the tape to ask questions or discuss material. This restriction was imposed both by scheduling constraints and by technical arrangements whereby the videotape was played to the classroom from a remote location so that frequent stopping of the tape was not feasible. At the end of each session, however, there was an opportunity to ask questions.

There were a total of 22 videotapes, each about 55 minutes in duration. Performance of all students was measured by midterm and final examinations and each exam was constructed by the combined efforts of the large class instructor and the TVI tutors.

2. Group Interaction Study and Observation Instrument

The emphasis in this experiment was on the frequency and nature of interactions that occurred in the TVI groups, together with the usual comparison of TVI student performance with that of the students in the control group. Since previous efforts had showed that the TVI tutor could not reliably take data about student interaction, the observation instrument was developed with coding to permit the observer of the group to note the nature, duration, source and recipient of each action in the group, whether stopping or rewinding the tape, asking questions, making comments, etc. Two observers were trained to use the observation instrument and tested for reliability by having both observers take data on the same TVI group for 3 sessions. A sample copy of the observation instrument and the explanation and coding for its use is given in Appendix A. Data on interactions in the TVI groups was then taken by the two observers for 8 sessions.

The data taken in the observed sessions showed that the TVI method was effective in stimulating group interaction. On the

average the tape was stopped 12.6 times per session in the low group and 7.6 times in the high group. Typically the TVI sessions lasted for approximately 20 minutes longer than the taped material because of the discussion that took place. Most of the questions had to do with clarification of the material (an average of about 44 for the low group and 42 for the high group each session), although many dealt with mathematics (on the average 26 per session for the low group and 22 for the high group). The tape was replayed only seldom; an average of 1.1 times per session for the low group and 0.5 times for the high, although this varied considerable from session to session.

For one-step interactions the data suggests that interaction was more student-initiated in the high TVI group, and that the low group asked a larger percentage of nonmathematical questions, made a larger percentage of nonclarification responses, and stopped the tape more.

In the study of extended (two-step) interactions it was found that the high and low groups were basically similar. Most question-response sequences were initiated by pupils, although the tutor did promote discussion by asking questions. Indicators of rich interaction (something other than a question followed by an answer) were moderately high. The data showed that longer exchanges in the discussion occurred in the high TVI group.

Variation in TVI interaction was examined using a 3-way analysis of variance. Results show that differences between pupils account for almost all of the variance, and that the low and high TVI groups interacted differently during the playing of the same tape.

3. Performance Results

Using class performance scores in the prerequisite prior course EES201A as a measure of ability, a scatter plot of EES201B performance as a function of ability is shown in Fig. 3.4. No significant differences were found between the control and combined TVI groups. To a large measure this may be due to the fact that most of the low ability students in the control group, comparable to the low TVI group, dropped the course, making a comparison virtually impossible. This in itself tends to confirm the previous results that the TVI method is most helpful for lower ability students, in that the low TVI students were able to successfully complete the course where the comparable low ability students in the control group did not. Other possible reasons for the lack of significant difference can be postulated. The power of the experiment was small because of the large variability of student ability and performance together with the small sample size. There may also have been unconscious coaching by the professor in the control group and the TVI tutors.

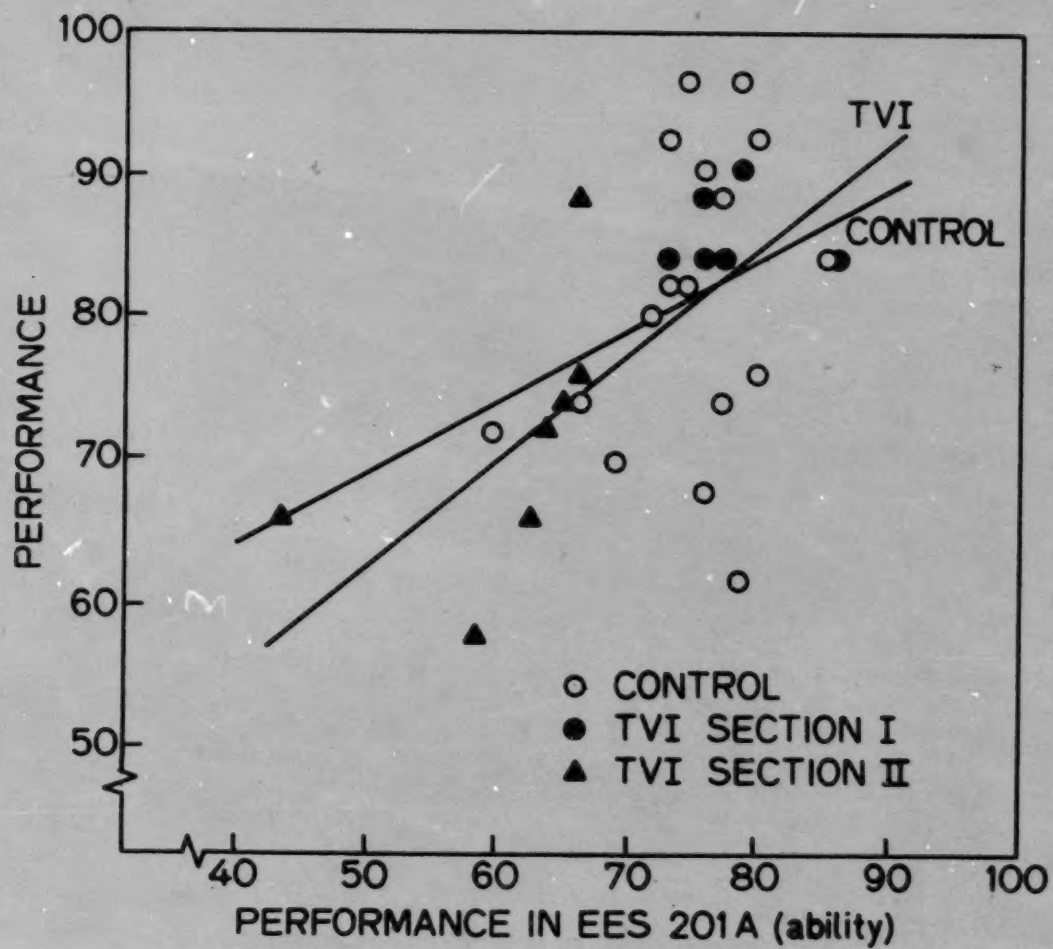


Figure 3.4 - STUDENT PERFORMANCE IN EES 201B (WINTER 1976)
VS PERFORMANCE IN EES 201A

In both TVI groups there was a positive correlation between the class performance and the number of interactions in the group, either asking or answering questions, as illustrated by Fig. 3.5. This result seems reasonable, although it does not agree with the result obtained with the TVI groups in EE221B where it was found that the students who did poorly in the class asked both the most and the least questions. Small sample size and wide variation of student ability and personality may be the cause of this, although the data shown in Fig 3.5 is taken from a more thorough interaction study.

In examining the relationships between interaction and performance the best predictor of performance in the low group was found to be students who responded to questions (which accounted for 45% of the performance variance, whereas precourse ability accounted for only 31%). For the low group all other variables were poor predictors of performance.

The high TVI group was characterized by high correlations between performance and other variables except ability and WHOM-Q (student to whom questions were directed). The low correlation between performance and ability is an artifact resulting from the restricted ability range, which also invalidates other results involving ability. We can conclude that for the high TVI group students who ask questions, respond to questions and to whom responses and questions were directed performed well. Students to whom questions were directed did not necessarily do well. It should be noted that students in the high TVI group were of essentially the same ability, which together with the positive correlation between performance and interaction suggests that for the high TVI group interaction affects learning. Low sample sizes cautions against placing too much weight on these results.

4. Student Attitudes Toward TVI

At the end of the course a questionnaire was completed by all students to assess attitudes toward the instructional method. Despite the lack of correlation between performance and method a striking difference was observed in student attitudes toward the use of videotape with and without the combined tutor and stopping features. These results are shown in Fig. 3.6, where the responses to several questions are recorded for the three groups of students ("low ability", "high ability", and control). Each question was answered on a preference scale which ran from +1 (strongly agree) to -1 (strongly disagree). Note that both TVI groups were enthusiastic about the instructional method, the high ability group even more so, while the control group which experienced the videotape without stopping for discussion was generally negative or indifferent although the course performance was almost identical to what it had been the previous quarter in the live lecture class.

Discussions with the two TVI tutors were also revealing. The questions and interactions in the low TVI group tended to provide expanded explanations or to fill in gaps in student background for

		1	2	3	4	5	6
Ability	1	1.000	.553	.364	.785	.224	.419
Performance	2	.553	1.000	.015	.668	-.087	-.013
WHO-Q	3	.364	.015	1.000	.318	.887	.984
WHO-R	4	.785	.668	.318	1.000	.205	.367
TO WHOM-Q	5	.224	-.087	.887	.205	1.000	.878
TO WHOM-R	6	.419	-.013	.984	.367	.878	1.000

(a) Low TVI

		1	2	3	4	5	6
Ability	1	1.000	-.193	.134	.090	.162	.021
Performance	2	-.193	1.000	.640	.754	.109	.793
WHO-Q	3	.134	.640	1.000	.580	.447	.971
WHO-R	4	.090	.754	.680	1.000	-.117	.745
TO WHOM-Q	5	.162	.109	.447	-.117	1.000	.329
TO WHOM-R	6	.021	.793	.971	.745	.329	1.000

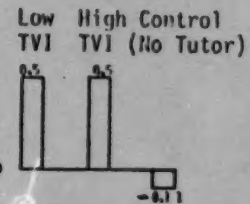
(b) High TVI

Code

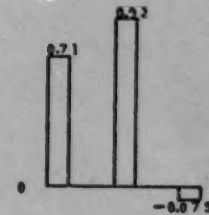
Ability	Total score in EES 201A
Performance	Total score in EES 201B
WHO-Q	Number of questions asked
WHO-R	Number of responses made
TO WHOM-Q	Number of questions directed to
TO WHOM-R	Number of responses directed to

Fig. 3.5 - Correlations of ability, performance, and interaction data for questions and responses categorized by WHO and TO WHOM (EES201B - Winter 1976).

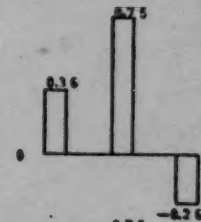
Feel more favorable toward this method of instruction at end of course than when course began:



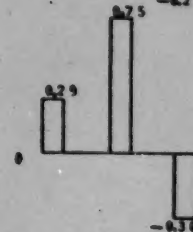
Prefer this method of instruction to lectures in large classrooms: (50 or more students)



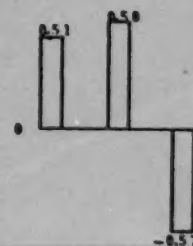
Learned more from this course than from other courses due to the instructional method:



Asked more questions in this class than in other classes:



Learned more from questions and comments of other students than in other courses:



Felt more free to ask questions and express myself than in other courses:

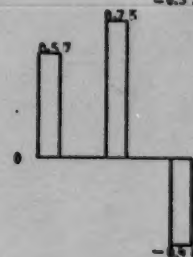


Fig. 3.6 - CAMPUS STUDENT ATTITUDES TOWARD TUTORED VIDEOTAPE INSTRUCTION
(EES 201B - Winter 1976)

material covered in the videotape lecture. The high TVI group, on the other hand, was comfortable and even impatient with the pace of the material on the videotape, and tended to use the discussions to expand the scope and explore related material, frequently challenging the tutor to cover material in more depth than was possible in the videotape designed for the average level of the larger class. The TVI method, therefore, tended to provide the type of instruction appropriate for the students at both extremes of ability, facilitating their tailoring the course to their respective needs and interests.

E. INTERVIEWS WITH OFF-CAMPUS TVI STUDENTS IN INDUSTRY

A final area of investigation under this contract was to conduct interviews with the TVI students in industry at the two locations where the method has been used over a significant period of time to assess the effectiveness with which the TVI method had been implemented and to determine student attitudes. Program use at these two locations was quite different, seemingly due to external factors such as time constraints, attitudes and educational backgrounds of students, and atmosphere of the company.

The first location was found, for various reasons, to be not conducive to encouraging stopping the tape for student and tutor interaction. Some of the tutors tended to feel that their time was not well spent in tutoring the TVI classes (though there were notable exceptions) and sometimes did not regularly attend the videotape sessions. For some courses the students watched the tape alone. According to the students interviewed, when watching the tape as a group seldom were questions asked or the tape stopped or replayed, and they seemed almost oblivious to the potential advantages of the TVI method. In response to "what are the key advantages to TVI classes" students answered "the picture seems to be clear", or "tapes arrive on time". When the interviewer explained the intention of the question the students would agree that it was helpful to stop the tape but elsewhere in the interview they would say they never stopped the tape. On the other hand when they watched the tape alone many said that they stopped the tape many times for note taking and to make sure they understood a point before moving on.

At the second location most of the students taking the TVI graduate program in electrical engineering had not had an electrical engineering undergraduate background and thus were deficient in circuit analysis and basic electronics. For example, they were unfamiliar with sophomore electrical engineering topics such as superposition and voltage dividers. However, all students seemed to be highly motivated. Some watched the tapes several times and met weekly to discuss homework. This company had a relaxed atmosphere; the lab manager in charge of education encouraged appropriate lab members to take courses and there was no feeling of competition

between work and school time. Viewing of the 50 minute tape often took up to 2 hours because of questions, discussion, and remedial instruction by the tutor. Extra problem sessions were frequently held. During a session there was much interaction; students often answered each other's questions.

When asked about their reactions to TVI instruction the following advantages were noted:

- a. Being able to stop the tape. Some questions can be answered in a few minutes while others require a problem session. Sometimes the tutor would stop the tape on his own even though no questions had been asked; in the discussion, however, each student would usually find there was something that was not understood.
- b. Convenience in timing of watching the tape. Unlike a conventional classroom where the student must adjust his schedule to meet a specified class time, the videotape can be viewed at any time. Also, if needed the tape can be viewed more than once and alone if desired. Viewing the tape alone was usually done to facilitate note taking by frequent tape stopping.
- c. Small class size
- d. Opportunity to explain to others
- e. Learning of the group's and his own strengths and weaknesses. This becomes particularly important when there is a desire to help each other. If one student is weak in mathematical derivations others are willing to provide assistance. In such an atmosphere it is easier for one to admit that he has a weakness and to accept help from others.

It was also noted that after students had experienced several TVI classes in which good tutoring and interaction was present, the students themselves took more initiative in stopping the tape and starting the interaction, making tutor selection and coaching less critical. The class became much more of a group effort where it was important to each member that all of the class understand the material. It was as though students had to unlearn habits of passive listening resulting from years in large lecture classes, where each student tends to be on his own and in competition with the rest of the class. One student indicated that he had initially been quite skeptical of the TVI program but after experiencing a class with good interaction was now convinced of the effectiveness of the TVI method.

F. SUMMARY

The purpose of this investigation has been to assess the initially favorable results obtained with the TVI method by several studies and experiments as described above. This work has supported the conclusion that the TVI technique is at least as effective as either classroom instruction or live TV with audio talkback capability, for both on-campus and off-campus students.

At this point our data is still not sufficiently extensive to permit a rigorous statistical test that TVI is superior to conventional classroom instruction, and indeed there are clearly situations in which TVI is not appropriate. Our data is consistent with the hypothesis that TVI can be at least as effective as the live classroom, however, and not only does it seem to offer particular advantages for students of lower ability or inadequate background, when well implemented TVI is perceived by students as being clearly desirable. This is consistent with results recently obtained by Anderson (6) in a much larger experiment, where he found that both student satisfaction and course performance tend to decrease as the delivery method is changed from on-campus lectures to live TV to non-tutored videotape.

We are also unable to generalize to subject areas other than engineering and science, although we believe the general principles of the TVI format will apply to a wide range to subjects and audiences.

It has been argued that the industrial experience of the TVI students accounted for their initially outstanding performance when this program was first begun in 1972. The TVI students were drawn from the same population as the students studying from live TV, whom they outperformed, so industrial experience and/or motivation cannot account for these results. Furthermore, the experiments described above show that on-campus students similarly do well with TVI and sometimes outperform on-campus students who attend the regular lectures. Hence the effectiveness of TVI is not limited to industrially-based off-campus students.

It is natural to question the degree to which the initially favorable results might have been due to a Hawthorne effect. In the continuation of this program the students who first began the TVI courses have continued to do well, some of them having now completed their MS degree in EE with creditable showing after 3 years or more in the program. It seems somewhat unlikely that the Hawthorne effect can be made to persist for this period of time.

IV. MANAGEMENT AND OPERATION OF THE STANFORD TVI PROGRAM

The development of the Stanford TVI program came about as a result of several contributing factors: the long experience with the part time industrial Honors Cooperative Program, the existence of the Stanford Instructional Television Network used with the HCP, the desire of local industry to provide continuing professional education for their engineers at plants too distant for participation in the SITN, the interest of Professor James F. Gibbons in educational methodology, and the cooperation and support of University administrators (in particular John Linvill, Chairman of the Department of Electrical Engineering, and William Kays, Dean of the School of engineering). Out of the experience gained during the several years of TVI program operation has evolved several procedures and management techniques that may be of interest to others who may be contemplating a similar program. In this section, therefore, we describe the present Stanford TVI program in some detail, pointing out some of the problem areas.

A. RESULTS WITH THE TVI PROGRAM CONTINUATION

Because of the initially encouraging results with the TVI program, University permission was granted to continue the program and to incorporate TVI courses into an accredited graduate engineering degree program. At the end of the 1975-76 school year, after three years of operation, there had been 28 industrial students at the Hewlett-Packard plant in Santa Rosa, California, who had taken at total of 1191 quarter-hours of graded course work with an overall GPA of 3.34. Some of these students were interested only in occasional courses as a means of upgrading their professional skills in particular areas and had either already completed or did not wish to pursue a graduate degree. Eighteen TVI students had been admitted to degree candidacy, and of these ten had completed their MSEE degrees with an overall GPA of 3.42. If we exclude from this group four students whose academic qualifications were below those normally required for Stanford admissions, the resulting GPA for the graduating industrial TVI students at Santa Rosa was an impressive 3.59, considerably above the overall average for Stanford MSEE graduates with comparable backgrounds. The four formally "unqualified" students had a very respectable average GPA of 3.16.

In the 1974-75 school year the TVI program was further expanded to include a Hewlett Packard Plant in San Diego, and in the Spring quarter, the Hewlett Packard plant in Boise, Idaho, adding some new dimensions to the program. In particular, the academic backgrounds and interests of the industrial students at these locations were very different from the Santa Rosa Students, who were all electrical engineering majors as undergraduates. By comparison, eight of the ten engineers taking courses at San Diego had their undergraduate degrees in such fields as Mechanical Engineering, Physics, Computer

Science and Chemical Engineering. With such varied backgrounds and in some cases marginal undergraduate grades the role of the local tutor became especially important for locating and filling gaps in assumed prior knowledge. Perhaps for this reason the San Diego plant has made the most thorough use of the technique of stopping the videotape for active class discussion and participation, sometimes spending as much as two hours to complete the 50 minute lecture. Seven of the San Diego Engineers have been admitted to the Stanford MSEE program and by June 1976 had completed 87 quarter hours of course work with an overall GPA of 3.17. The Boise industrial students also have varied backgrounds and academic preparation; however, the Boise plant is sufficiently new that the program has not yet reached the necessary level of stability to permit meaningful data to be gathered.

The situation at the fourth TVI location, the Sandia Corporation in Albuquerque, is also different from the three HP locations and adds further dimensions to the evaluation of TVI as an instructional methodology. Sandia has a highly developed in-house continuing education program, and most of the professional engineers either have advanced engineering degrees or do not wish to pursue an MSEE degree at Stanford. Instead, the program has been used as a continuing education opportunity in selected areas by mature professionals, usually only taking a few courses of particular interest, or in a few cases as a means of preparation for and entry into a Stanford PhD program. Few of the Sandia students have requested formal admission into the Stanford graduate program; nevertheless, the results of the program seem to have been favorable. By the end of the 1975-76 school year a total of 423 graded quarter-units had been completed by Sandia students with an overall GPA of 3.58.

In summary, during the first three years of operation of the TVI program, a total of 1803 quarter-units of graded graduate engineering course work, plus a considerable number of ungraded seminars and audited courses, had been completed by industrial students. Their overall GPA for this work is 3.37, and their response to the TVI technique has for the most part been enthusiastic. On the basis of these results it seems reasonable to conclude that, for science and engineering courses, the TVI format is at least as good as other methods of delivery with which it has been compared. The Stanford program is continuing and seems to have the potential for further growth. A number of areas require careful attention for successful program operation, however, as will be discussed below.

B. TVI PROGRAM INITIATION AT STANFORD

The TVI program was initiated at the request of and to fulfill needs for continuing education by practicing professional engineers in industry. From the outset it was intended that the TVI program, if successful, would provide accredited courses leading to a graduate

degree; for this reason it was important that the TVI method provide an educational experience equivalent to on-campus classroom education. It was also essential that the program be financially viable by acceptable charges that would cover the costs of the program, since no government or other outside funding was involved, and that it impose no unacceptable burden upon the normal functioning of the University. Several factors contributed to making a program satisfying these needs feasible, as listed below.

1. The Existing Honors Cooperative Program (HCP)

As mentioned above in Sec. I, the HCP with local industry had long been in existence at Stanford, permitting part time study for engineering professionals in accredited programs leading to graduate degrees. Administrative arrangements and agreements with local participating industry were already in existence which were also appropriate for the proposed TVI program, minimizing the need for developing new arrangements. In addition to accredited HCP courses, existing mechanisms permitted both non-credit graded course participation in the Non Registered Option (NRO) as well as essentially unlimited auditing. It was necessary therefore only to integrate the new TVI program with the existing HCP.

2. Use of the Stanford Instructional Television (SITN) Facilities

Because the needs of the HCP had led to the installation of the four channel instructional television system which had been in operation since 1969 [1], little was needed in the way of additional facilities to implement the TVI program. Included in the SITN were five originating studio classrooms which were in regular use by the network. Both instructors and on-campus students were familiar and comfortable with class presentations in these rooms, which had intentionally been designed to be congenial and well equipped for instructional purposes, with little feeling of being in a television studio and minimum intrusion by camera operation on class functioning. Since the television video signals from all of these studio classrooms were sent by closed circuit television cables to a master control room for monitoring and transmission to the remote ITFS transmitters, it was a simple and relatively inexpensive matter to install additional videotape recorders to obtain the tapes for the TVI classes. An additional part time student staff member was added to deal with handling and mailing videotapes to the TVI companies, and another to assist in recording tapes.

To date only monochrome television has been used in the SITN and hence in the TVI courses. This partly for reasons of cost and complexity of color equipment. Also in part is the need for greater skill on the part of camera operators to achieve good color, as well as the higher light levels required in the classrooms at the time of system installation. It was felt that poor color would be more

distracting and objectionable than no color at all, and for most of the classroom presentations the lack of color has not seemed to be a disadvantage. Occasionally the use of visual aids such as color slides or viewgraphs, particularly in seminars with guest speakers, would be enhanced by color; to date this need has not been sufficient to justify the additional complexity and cost.

Similarly it has been found quite adequate to use half inch reel to reel videotape equipment for the TVI courses. Not only is the tape, recording and playback equipment less expensive than, say for example use of 3/4" cassettes, with the equipment available to date the stopping, rewinding and replay of lecture portions is faster and easier using the reel-to-reel videotape equipment than with cassette equipment (although this may not be true in the future as tape equipment improves). While it is easier to abuse and damage the tape with reel-to-reel than cassette equipment, this has not proved to be a problem.

3. Use of Existing, Live, Unedited On-Campus Classes

Many applications of televised instruction make use of highly produced, scripted and edited courseware. Such production is very expensive; studio facilities, production teams and polished camera work can cost thousands of dollars per course-hour. From the outset it was considered that such production techniques were not feasible for the SITN HCP program. Instead, unedited transmission direct from the classroom where on-campus students were attending the class has been employed, with provision for permitting questions in the classroom from the remote students attending the course by live television. It is certainly true that in this situation instructors sometimes make errors, there is wasted time in dealing with mechanics of the class, and visual aids such as chalkboard or writing on a pad under an overhead camera is sometimes not as neat or legible as materials prepared in advance.

There are compensations, however. Production costs are minimal since only a student classroom camera operator is required, no editing is done, and there is no production team assisting the instructor. Aside from costs, however, it has been our experience that the live tape, with all its imperfections, has a presence and "liveness" that give the videotape viewer the impression that he is participating in a live class that is more interesting and less tiring than a more compact "produced" class. Certainly the interaction of an instructor with a live class tends to stimulate a superior presentation than talking only to a camera. Some instructors are better at this than others, and some classes are more suited to being televised because of the nature of the material and needed outside facilities (such as computers) than others. Because many Stanford instructors had taught classes many times in the SITN classrooms and were familiar with effective media use,

few changes in technique were required to permit taping of existing courses for the TVI program, and the economics were favorable.

In order to assess the suitability of the TVI courses for academic credit, from the outset of the program it was intended that the TVI students do the same problems, exercises and examinations and to be graded along with the on-campus students taking the same course. This was feasible because the number of TVI students was small enough that the additional grading burden was not excessive. It also insured that the TVI students were graded on the same scale as the regular on-campus students. It meant, however, that time delays introduced by the mailing of tapes to the TVI companies and the return of homework and examinations to the campus could create problems, as will be discussed further below. It also meant that tapes are not saved and replayed in order to offer the same course again; with a few exceptions the tapes were erased and each TVI course was recorded live at the time the course was given on campus. This is not to say, however, that the TVI technique could not be effectively used with a library of courseware; given careful attention to problems of developing and grading homework and exams the same tapes could be used repeatedly. To date, however, the Stanford TVI program has not functioned in this manner.

4. Arrangements in the TVI Companies

The basic requirements for the TVI program in the participating organizations were that they provide a local tutor to meet with the TVI students, one or more meeting rooms equipped with a videotape playback unit and a television monitor, and a liaison person or coordinator to handle details of enrollments, scheduling, and communication with Stanford. Matters such as whether the videotapes were viewed during or outside of working hours, whether students paid all, part, or none of the fees for courses taken for academic credit in a degree program, as an NRO, or as an auditor were between the organization and the TVI student. Attention to handling of tapes, handouts, homework, examinations, and acquisition of textbooks also required attention.

5. Financial Arrangements

The financial viability of the TVI program required that fees for the TVI courses adequately cover program costs, but at the same time not impose unacceptable costs on the participating students or their employers. It had long been established that tuition alone does not cover actual costs of graduate engineering instruction in the HCP, and that the University was not in a position to subsidize part time nonresident graduate industrial students. Recognizing this, companies participating in the HCP had agreed to pay additional fees to cover both actual academic costs and the costs of operating the instructional television network. This fee structure was

appropriate and acceptable for the TVI program with the addition only of a fee to cover the additional costs of taping the TVI courses. By taping existing courses already being televised by the SITN and by recycling tapes the additional charge for the TVI program to cover tape and equipment amortization, taping labor, postage and handling, management and travel was determined to be \$12 per course hour, regardless of the number of students at any one location.

C. TVI PROGRAM MANAGEMENT

Integration of the TVI program into the existing academic, HCP and SITN programs at Stanford had the definite advantage of requiring a minimum of new physical facilities and administrative arrangements, permitting rapid implementation that might otherwise have been much more difficult. It also had the result, however, that it posed new requirements on each of these programs and required some negotiation and continuing attention so that the integration could proceed smoothly with minimum disruption. A key requirement is a TVI Coordinator on the campus to work with all of the concerned constituencies, keep abreast of the progress of the TVI program, and to act as a troubleshooter and contact person when problems arise.

In this section we discuss some of the concerns of the various constituencies involved in the TVI program at Stanford.

1. The TVI Students in Industry

Our foremost concern is with the TVI students themselves, since they are the *raison d'être* for the whole program. In the Stanford TVI program many students have been young professional engineers, out of school for one or more years, working full time as practicing engineers with varying degrees of company responsibility, sometimes with families. Usually they are interested in improving their technical competence, possibly to obtain an advanced academic degree, and with many demands on their time. Company requirements come first and when job pressures mount the academic work frequently takes second or third place when family responsibilities are also a factor.

Under these conditions the entry into a graduate degree program is a significant undertaking. With the minimum of 42 quarter units required at Stanford for an MS degree, typically about 14 courses are needed; taking one or two courses per quarter can thus lead to a degree program lasting for several years, during which time requirements for the job, doing homework, and relating to a family can be very demanding. Motivation is a key. Most engineers understand that continuing education is essential if their technical skills are not to become obsolete, but the fact remains that learning can be hard work and much perseverance is required. These considerations are not unique to TVI, but a TVI or any other continuing education program should provide as much encouragement

and assistance as possible. There is a great temptation to start a course with the best of intentions but to lag behind with homework, miss class sessions, and finally drop out as job pressures take precedence. For example, it seems to be the rare individual who can audit a course just to learn the material, with no commitment to take examinations and do homework or get a grade, with little financial investment, and still get much out of the course or even complete it. The attitude of his employer and arrangements for taking part in the TVI program (such as financial reimbursement for tuition fees, released time to attend classes, recognition of TVI involvement in work expectations, etc.) can also have a great effect on student motivation.

The Stanford TVI program as it has evolved thus is designed to offer a number of incentives for course completion. Continuing education for improving professional competence is made available by university level graduate courses taken in a convenient manner in company with his fellow workers. When properly implemented, the TVI method with the active interaction with fellow students and the tutor in the TVI group can provide a stimulating and enjoyable learning experience. In particular the tutor can bring in supplementary material related to the job situation that makes perceived relevance high. Entry into a formal degree program is open to those students with adequate background and ability; for those students with marginal or substandard backgrounds or changing from other fields, the NRO option permits accredited work that if satisfactorily completed can be used to gain admission to a graduate program that might otherwise not be permitted. The time pressure of regularly scheduled classes, homework assignments, and examinations as well as working along with the rest of the group helps to maintain the student involvement and interest which might otherwise slip if the student were free to follow his own pace, where it easy to let other interests and pressures take precedence. Moreover, the flexibility of the TVI method, with the freedom it provides in scheduling, making up missed lectures, replaying the tape to aid in understanding, etc. is a definite advantage over the rigid schedule of live campus or televised courses.

It is important that the student not get the impression that because he is away from the campus he is in some sense a "second class" student in the eyes of the instructor or the University. The attitude he perceives when dealing with any part of the University will have much to do with his satisfaction with the program, and it is the job of the TVI Coordinator to insure that his interests are recognized.

2. The TVI Tutor

To a considerable degree the effectiveness of the TVI program depends upon the on-site tutor. A good tutor is able to answer most

of the student questions, act as a link to the campus instructor, facilitate course mechanics, be aware of student progress and difficulties, and in general facilitate the creation of an "educational community" atmosphere in which students become interested both in understanding the course material themselves and in assisting others in the group who may be having difficulty.

Because of the importance of the tutor in the TVI method, tutor selection should be done with care. Two situations have arisen in the Stanford TVI program. In the off-campus organizations that have been receiving TVI courses, the tutors are drawn from the staff of the organization. For the relatively few number of on-campus TVI courses the tutors have been carefully selected graduate students, usually PhD candidates who have an interest in teaching as a career. Generally it has been found that the same person should not be asked to serve as a tutor for several successive classes, since job pressures and reduced personal interest tend to diminish tutor effectiveness. Exceptions have been found, however, who seem to enjoy the tutor role.

Initially an elaborate selection process was set up for obtaining the company tutors involving complete academic and employment records, at least two reference letters, recommendation by the company supervisor and an interview with the Stanford TVI coordinator prior to the beginning of the course. This was found to be too cumbersome and not really necessary; after some experience with the program the company manager, who understood the qualifications needed and knew the backgrounds and work loads of his personnel, recommended one or more potential tutors for each proposed TVI course who were then interviewed by the Stanford TVI Coordinator and given suggestions as to tutoring technique.

The tutor should have a good grasp of the subject matter of the course and also have an interest in helping students learn the material. What seems to work best is for the tutor not only to have had the same or similar course before (or have had equivalent experience) but also to have some personal interest in reviewing the subject matter. The tutor should have the type of personality that encourages students to ask questions and seek assistance. Exceptional technical competence is less important than willingness to work with the students, since questions the tutor is unable to answer can be handled by direct contact with the instructor. The tutor should not be a person so busy or so senior in the organization that he or she does not have time to attend videotape sessions or be available for questions outside of class.

The tutor should plan to attend each videotape class session. It is important that the tutor encourage students to stop the tape when questions arise, and to be alert to points that need clarification if there is a perceived lack of student understanding. The tutor should stop the tape and ask questions to initiate discussion if needed.

In the Stanford program where the TVI class parallels the class on-campus the tutor is encouraged to contact the instructor early in the quarter either by phone or by a visit to the campus to establish contact and deal with questions of course mechanics, homework and examination policies, determine office hours, name of course grader and teaching assistant, if any, make arrangements for computer or other facilities if needed, etc. The tutor should feel free to call the instructor, course grader, television network, or campus TVI coordinator if problems arise.

Ideally the tutor should be aware of the background and progress of each student in the TVI group. Graded homework and examinations should be returned through the tutor so that he can review student performance and deal with difficulties before they become serious. If homework is late or omitted the tutor should check with the student as to reasons.

The tutor can augment the course and increase the value to his students by arranging for demonstrations or experiments at the organization that relate the course material to applications. On occasion such demonstrations have been incorporated into the on-campus course to the mutual benefit of both TVI and campus students.

It is valuable for the tutor to formulate some review questions before examinations. Off-campus TVI students are sometimes at a disadvantage compared to on-campus full time students since the latter are more accustomed to examination pressures.

Evaluation of the course and instructor is important for the continued improvement of the TVI program. The tutor asked to make an evaluation and to administer a brief questionnaire to the students in the group at the end of the course.

Careful thought needs to be given to providing motivation for the TVI tutor. Some people enjoy the tutor role and do it well; their efforts, however, need to be recognized as a valuable contribution to the organization and not just something to be added on to their other job responsibilities.

3. The Course Instructor, Secretary, Teaching Assistant and Grader

The instructor of a graduate engineering course at a university is typically a busy person with many demands on his or her time. Typically there are one or more courses to teach with many on-campus students, research commitments with advanced graduate students in PhD programs, university committees and administrative work, and sometimes outside involvements to industry or government activities. In order to use the instructor's time most effectively and still maintain contact with the on-campus students, the instructor will typically have regular office hours, a secretary to handle telephone calls, scheduling, preparation of class materials such as handouts or

problems, a graduate student to grade homework problems (with the instructor usually grading examinations himself), and in some cases a teaching assistant for large classes with a laboratory or discussion sections.

Potentially the TVI program can increase the educational productivity of the instructor by increasing the number of students who can participate in the class without making the on-campus class unwieldy. Teaching methods and style need not change; there is a greater adjustment in the addition of live television HCP students than in the further addition of TVI, although the SITN studio classrooms and system have been designed to minimize the adaptation needed and in fact, with the overhead camera and other facilities, make teaching techniques such as use of a pad instead of the chalkboard and in-class demonstrations and use of visual aids much easier than in the normal classroom. It is helpful if the instructor minimizes the amount of classroom time devoted to mechanics and administrative matters relevant only to the on-campus students, avoids referring to future or past classes by day (since the TVI students may be on a different schedule), but these are minor matters to which the TVI students easily accommodate.

It has been our experience that the addition of TVI students to the class enrollment does significantly increase the teaching burden on the instructor, however, and that this must be recognized if continued instructor cooperation is to be maintained. Sometimes special arrangements need to be made for class notes, access to computer facilities, and the like. TVI students and tutors are encouraged to contact the instructor by phone if necessary, but they should be aware that his time is valuable and use regular office hours if possible. The most demanding aspect of the TVI program as it has been implemented at Stanford is the late grading of homework and examinations received from the TVI students because of mail delays and the fact that they typically watch the classes up to a week after the on-campus lectures. It is surprisingly difficult to get back into the frame of reference of grading a few papers received after the bulk of the class has been graded. Since grading the TVI students in comparison with the regular class is an integral part of the giving of academic credit, we have found no solution for this problem other than to minimize the delays as much as possible and to try to communicate to the TVI students that they cannot be casual about turning in homework and taking examinations on time. Under active consideration at the present time is the initiation of instructor reimbursement from a portion of the TVI fees to compensate for the added teaching burden.

Similarly, time delays impose somewhat on the graders of course homework, when used. Their help is asked in several ways:

- a. While not asked to give priority or special treatment to the TVI students, they are encouraged not to give in to the temptation to set TVI homework aside and create further delays since it typically will arrive after the rest of the class has been graded. To aid in this the TVI papers are clearly stamped "VIDEOTAPE STUDENT - PLEASE EXPEDITE".
- b. In order to monitor the academic quality of the videotape instruction by comparison with the rest of the class, the graders are asked to compute the class average of homework homework scores for the whole class and send this information to the University TVI Coordinator.
- c. The graders are asked to keep in mind that the TVI students do not have easy access to the course instructor and to therefore be generous with comments about nature of their errors.

In return for this help the graders are given a fee for each TVI student in addition to their normal pay. They are specifically instructed not to grade the TVI students any differently than the rest of the class, however.

The secretary to the instructor and the Teaching Assistant, if any, are also alerted to the existence of the TVI students. The secretary needs to be aware of the additional needs for handouts and to be particularly careful that they are clearly legible, since it is more difficult for the TVI students to obtain clarification. Since the live television students come to the campus to take examinations with the rest of the class, the secretary or instructor must remember to send examinations to the remote students in sealed envelopes marked with the course number, title of the examination, time limit, and special instructions.

Since final examinations and end-of-course homework from the TVI students are usually received after the deadline for turning in course grades to the University Registrar, a grade of I (Incomplete) is typically filed until grading is complete, at which time a change of grade is made for the regularly registered TVI students. Care must be taken to insure that this is not overlooked. Grades for the NRO students are maintained by the television network, so that these can be recorded whenever appropriate.

4. The Stanford Instructional Television Network

As mentioned above, the prior existence of the SITN greatly facilitated the initiation of the TVI program. Camera-equipped studio classrooms were already in use by classes for the live HCP television program. Since the program video from these classes all converged at the Master Control Room for the network, it was a relatively simple matter to install videotape recorders to obtain the tapes to be sent to the TVI companies. As the program expanded

it was necessary to increase the room available for the taping, but otherwise it was not necessary to modify the physical facilities, technical equipment, or procedures for handling course software.

A part time student assistant was added to the staff to assist the engineer on duty in the SITN Master Control in making the tapes, since the necessity for integrating the taping with the regular class schedules sometimes meant that a considerable number of recordings needed to be started or changed in a very short time. To maximize recording quality, minimize delays, equipment and personnel costs, and to simplify procedures all TVI tapes were recorded live, rather than making a master tape and later making multiple copies if required. A second part time assistant was added to the SITN staff to handle logging and mailing of tapes and course software, receive and log materials returned from the TVI companies, and insure that returned homework assignments and examinations were routed to the appropriate campus offices. Except for late afternoon seminars it has been possible to get videotapes in the mail to the TVI companies the same day as recorded.

In other respects the TVI program integrated into the normal functioning of the SITN. Since typically about 50 courses are offered live by the SITN in a normal quarter, there existed a considerable number of courses from which to choose which could be easily videotaped for the relatively small number of TVI students in the program. The choice was not unlimited, however, and certainly much smaller than the number of courses available if the student were in residence on campus. The arrangements for the TVI students is little different from the regular live TV students. A SITN campus courier makes daily rounds to academic offices to pick up and deliver class materials such as handouts and homework. Billing procedures and records for the TVI companies are also similar to those for the regular HCP companies. In regular touch with the operation of the SITN as it related to the TVI program is the TVI Campus Coordinator, described below.

5. TVI and the University Administration

Integration of the TVI program into University procedures was greatly facilitated by the long existence of the HCP and the later establishment of the SITN, the latter having been in operation for four years prior to the start of the TVI experiment. The faculty and administration were agreed that the HCP students were in an accredited graduate degree program, so that the main concern was that academic quality of courses and programs would be maintained. Since the initial results with the TVI students was equivalent to and even superior to comparable on-campus students, the Dean of Graduate Studies, concerned department chairmen and the Engineering Dean agreed to give academic credit for the off-campus TVI courses with the proviso that careful monitoring of the program would be maintained.

As with any university the size of Stanford, however, there are a number of procedures and regulations designed to facilitate smooth admission, quarterly registration, provision of student services, and graduation of the more than 10,000 on-campus students, some of which are not appropriate for the TVI program. With the cooperation of the University Registrar's office, Department and School personnel and other concerned administration adjustments have been and continue to be made to eliminate unnecessary red tape and expense for the TVI companies and students. There was little problem with students taking courses in the Non Registered Option (NRO) or as auditors, since registration and records for these students are handled by the SITN with little contact with the regular University procedures. For HCP TVI students formally admitted to a degree program, however, some new arrangements and procedures were necessary. Some of these include the following:

- a. Admission to matriculated status: Since many graduate students are admitted by mail before coming to the campus, procedures were essentially unchanged for the TVI students. A requirement for submission of a Graduate Record Examination score, normally waived for industrial professionals in the HCP, was reinstated for the TVI students in order to give a better basis for evaluation of admission qualifications and assessment of the TVI program. The academic major department needs to be informed that the incoming students will be in the TVI category and not be attending classes on the campus.
- b. Quarterly registration: Normally all matriculated students register for courses on the campus, including those in the HCP. Because of the distance this was not reasonable for the TVI students. Fortunately a procedure (including the necessary forms) already existed for registration in absentia so that with the Registrar's permission this was used for the TVI students as well. Payment of tuition and other fees could either accompany the absentia registration forms or could be deferred by petition, since the TVI students were reimbursed in whole or in part for their fees by their organizations upon successful completion of their courses.
- c. Withdrawal, dropping courses, or changing to audit: Students on campus may change their registration and obtain a refund of fees paid within two weeks, or later with partial refund. Since the TVI students typically watched videotapes up to a week after the class was held on campus, this gave little time to decide whether the class was appropriate and caused some misunderstandings early in the program. With the agreement of the Registrar these deadlines were delayed by one week for the remote TVI students.
- d. Grades: The usual procedure for on-campus students is to receive grades for the previous quarter in their registration materials which they receive on registration day for each

quarter. Since the TVI students did not come to campus to receive these materials and in some cases their grades were delayed because of late receipt of the prior quarter homework and examinations, arrangements were made with their major department to send grades to them at their organization so that they could get reimbursed for their fees.

- e. Books: Normally the campus bookstore stocks textbooks and materials for all classes, but has a recurring problem with variation of class size both on and off the campus. It is important that the bookstore be given the best estimate possible of expected class size and that they understand that the TVI students are bone fide registered students, since otherwise there is a tendency for bookstore personnel to defer orders from the off-campus TVI organizations until all on-campus needs are met.
- f. Physical Examinations: All on-campus students are required to have physical examinations and records of inoculations when first admitted, since the student health service assumes responsibility for health care. For HCP students in the Stanford area the physical examination is waived but a health history is still required since the students are free to come to campus and use student services. Failure to have these records on file results in having a Hold placed on registration, a significant irritant to the TVI students. Special arrangements were necessary for the TVI students at remote companies to avoid such holds since both the TVI students and their organizations felt that the requirement of a health history and inoculations for the students that would never attend classes on campus was not reasonable.

While none of these and similar administrative matters were serious problems, they are typical of details that need to be handled by someone concerned with the interests of the TVI students and their organizations.

6. TVI Program Management in Industry

The original impetus for the TVI program came as a result of a request by industry remote from the Stanford campus to provide the same continuing education opportunity that had long been available through the Stanford HCP to organizations in the San Francisco Bay area. Industrial management recognized the value of continuing education for their professional engineering employees and was willing to pay a substantial part of the costs involved. At the same time management was concerned with the cost effectiveness of the program and with integrating continuing education into the operation of their organization with minimum disruption to normal plant operation and productivity.

The company needs to provide facilities for viewing the instructional recordings by the TVI groups; this usually consists of one or more conference rooms equipped with videotape player, suitable viewing monitor, chalkboard, chairs and table. The program works most smoothly when TVI viewing rooms are dedicated to this purpose; sharing a general purpose conference room or cafeteria creates scheduling problems, movement of furniture, and interruptions that result in continual irritation.

In addition to the viewing facility, the company provides the TVI tutor, as discussed above. Policy decisions need to be made as to whether videotapes are viewed during or after working hours, whether TVI students pay a portion of the course fees, who buys the textbooks and other supplies, and whether there is any compensation or inducement for the tutors to participate in the program. For a continuing program it seems to work best if tapes can be viewed during working hours with enough time scheduled to permit discussion for up to 30 minutes longer than the taped lecture, the class meets regularly at the same time (whether all students can be present every time or not), the tutor meets regularly with the group when the tapes are viewed, and the students have some financial investment in completing a course with a creditable showing.

The company needs to provide a coordinator or liaison person for the TVI program who is directly responsible to management. The coordinator assists students in required paperwork for admission and registration, informs Stanford of course selections, sees that textbooks and course materials are obtained, contacts prospective students to arrange for courses, and keeps in close touch with the TV network and the Campus Coordinator. When problems arise, as they will (such as lost homework or examinations, registration problems, faulty tapes or illegible handouts, student questions about courses or their academic programs, etc.), the coordinator acts as a focal person to contact the appropriate campus or company personnel. In addition to the coordinator there needs to be clear responsibility for handling of tapes, homework, handouts, and examinations so that these do not get delayed or mislaid in company mail channels.

7. The TVI Campus Coordinator

Because of the many different constituencies and possible sources for error when the TVI program is integrated with regular University functioning, it is important that there be one person who has the primary responsibility for overseeing the program whom we have termed the TVI Campus Coordinator (TCC). The TCC needs to be able to work with the TV network, faculty, graders, secretaries to faculty, academic departments, the University Admissions Office and other involved parties on the campus. In addition, the TCC needs to be in regular touch with management, coordinators, students and tutors at the remote companies. The TCC should be thoroughly familiar with the academic program so as to be able to act as program adviser to the TVI students, be aware of TVI student progress in their

academic programs, anticipate potential problems, and be a focal point for all concerned parties to contact. Continuing evaluation and improvement of the TVI program is a TCC responsibility.

On the campus the TCC has a number of functions. It is important that the TCC contact each TVI course instructor at the beginning of the quarter (particularly if the instructor has not taught a TVI course before) to explain the program, determine special requirements for the course (such as use of the campus computer or laboratory facilities) that might create problems, learn names of graders and teaching assistants, and generally offer to assist the instructor with TVI problems. It is desirable to obtain instructor agreement to provide class grade data to permit comparative evaluation of the TVI student performance with that of on-campus students. The TCC should also contact the instructor's secretary, course teaching assistant and grader(s) (if any) to explain the TVI program and any special arrangements needed. The TCC should then regularly monitor the quality of the videotapes and courses, performance of the TVI students, be alert to special problems and situations, and report the status of and be available to discuss the TVI program with the faculty, appropriate University administrators, and official visitors. The TCC should represent the interests of the TVI students in cases of grading errors, petitions, and administrative misunderstandings.

The TCC makes regular visits to the TVI companies at least once each quarter, usually at the time when it becomes appropriate to make decisions about course enrollments for the next quarter. The preferred time for this is about one month prior to campus registration in order to allow time for scheduling classes in TV classrooms, making videotape arrangements, selecting tutors, etc. When at the company the TCC talks to TVI students in the role of their academic advisor for program planning, interviews and explains the tutoring role to prospective TVI tutors, confers with management and the TVI company coordinator as appropriate. The TCC also talks to the TVI students and tutors for the prior quarter to obtain comments and evaluation of the courses, instructor and tutor performance, and to learn of any problems in the program.

At Stanford the TCC has also been involved in on-campus research experiments to assess the effectiveness of and ways to improve the TVI program, such as those described in this report.

The central role of the TCC suggests selection of a person for this position having a variety of qualifications. The TCC should be interested in educational effectiveness and methodology, have a background of television teaching, be thoroughly familiar with the academic program and University administrative procedures, be able to work with faculty, students and administrators both at the campus and the company, be comfortable with computers both for record

maintenance and as they are used in connection with courses and for program evaluation. It helps if the TCC is a relatively senior person at the University. The Stanford TCC had taught both graduate and undergraduate engineering courses (including a number of televised courses), participated in the design of and served as a technical adviser to the television network since its inception, held an administrative position in the Electrical Engineering Department, was a member of the academic council, and had the rank of Adjunct Professor of Electrical Engineering. The assignment as TCC was a 50% time appointment supported by TVI program income.

8. TVI Records

To expedite operation and evaluation of the TVI program the development and maintenance of a number of records has been found very useful and important to monitoring the program. Use of the Stanford time-sharing computer facility has been of great assistance to maintaining these records because of the ease of updating and printing copies of records with the editing capability of the computer. Among these records are the following:

- a. A record for each quarter by course and TVI student which is regularly updated during the quarter and which includes the students name, company affiliation, status in the course (admitted degree student, NRO, or audit), name of course, instructor, quarter taken, tutor, performance on examinations and homework in relation to the rest of the on-campus class, grade and standing in the course.
- b. A cumulative record for each TVI student of the same data as in (a) together with the quarterly and cumulative grade point average.
- c. A TVI student history which shows prior academic institutions and performance, graduate record examination results, dates and type of enrollment (NRO or HCP), and number of units registered by quarter over the time the program has been in operation.
- d. An explanation of coding used in (a) and (b), together with a record by quarter of TVI instructors and courses.

These records have been of great value in obtaining data for the continuing assessment of the program, particularly as the program has extended over several years. The sorting and text editing capability of the computer makes processing of data for various studies and evaluation of the TVI program easy and convenient and facilitates distribution of updated records to appropriate parties. The records can also be useful for providing tutors with information about previous performance and strengths and/or weaknesses of the students in the group.

9. Program Planning for the TVI Students

As mentioned above, an important feature of the TVI program at Stanford is the offering of academic credit which can lead to the completion of an advanced degree. To date the program has primarily been used for obtaining an MSEE degree, although it could also be used for MS degrees in other engineering disciplines and for partial fulfillment of requirements for the degree of Engineer. In the case of advanced students the TVI program has been used to complete course work at the company of the student in preparation for admission to a PhD program, in which case the student plans to come to the campus in residency for completing the doctoral research.

In some cases the prospective student may be unsure whether he or she wishes to enter a formal degree program or may have admission qualifications that are marginal. In this case we encourage the student to take several courses as an NRO (Non-Registered Option) since the work and grading are the same as if the courses were taken for credit as a matriculated student. Satisfactory performance in the NRO courses is then considered when evaluating admission, and up to 18 NRO units (6 courses) may be transferred to the MS program upon request with the payment of the appropriate tuition.

The number and variety of courses offered by the SITN make it possible to use TVI courses to complete all the requirements for the MSEE degree at the company, and several industrial students have done this. In brief, the Stanford MSEE program guidelines include the following:

- a. A "depth" sequence of at least three courses in a particular field (such as Electronic Circuits and Devices, Computer Systems, etc.).
- b. Three courses each in different fields than the depth field in order to provide "breadth" in EE.
- c. A total of 21 quarter-units (7 courses) in EE of prescribed level.
- d. At least three courses in departments other than EE.
- f. Additional courses to bring the total to 42 units, of which at least 36 must have letter grades.

There is no Master's Thesis required at Stanford for the MSEE degree, although the student may elect to do a project under faculty supervision if desired. Normally the completion of the above guidelines with an average grade of B (3.00) or better will result in faculty recommendation for the degree. The degree of Engineer requires more advanced courses, a substantial thesis project (which in theory might be done with faculty supervision on a company-related

project in part or totally at the company), and a somewhat higher grade point average for 42 or more units beyond the MS degree.

While it is possible for the student to totally fulfill the MS degree guidelines by TVI courses at the company without coming to the campus, this is not particularly recommended for a number of reasons. The variety of courses offered in the Stanford engineering program is far too large for the number of television classrooms available, even with four simultaneous classes throughout the daylight hours. Some graduate courses, such as laboratory classes, small seminars, classes requiring special computer or other facilities, etc. are not suited to television. Sometimes the TVI student wishes to design a program which combines engineering with courses in another department or school (e.g. in the Graduate School of Business) which does not teach television courses. For some advanced graduate courses it is difficult to find suitable tutors or enough students at the company to form an effective TVI group. Moreover, we feel that it is valuable for the student to become well acquainted with one or more of the faculty, fellow graduate students, and to experience the activities and atmosphere of the campus. We therefore recommend that the TVI students plan to come to the campus in residence for one quarter to experience those courses only available or best taken on the campus, and a number of the TVI industrial students have done this with the approval and support of their company.

In order to plan a coherent degree program, graduate students are required by their department to propose a complete program fulfilling the departmental guidelines by the time that they have completed no more than 15 units. Since there is some uncertainty as to which courses will be available on television and hence suitable for TVI, it is difficult for the industrial students to make such plans far in advance. It is also sometimes hard to know precise prerequisites and course content from catalog descriptions. The TCC as faculty adviser can assist such planning. It is also a simple matter to alter by petition an approved degree program by substitution of preferred courses at a later time, as long as the basic guidelines are followed. Adequate course descriptions are important for the TVI program, however.

10. TVI Problem Areas

In the three years that the TVI program has been in operation at Stanford a number of problems have been encountered, some easily solved and others of a more fundamental nature. To assist others who may be contemplating a similar TVI program we list some of these problems here.

A basic difficulty in the operation of the Stanford TVI program is the delay inherent in having the remote TVI students taking the same course and being graded along with the on-campus students.

Since the videotapes are sent to the TVI companies by mail, the off-campus TVI students watch the lectures up to a week after the class is given on campus. This means that homework assignments and examinations are also completed up to a week late, plus the added mail delay in returning papers to the campus and distributing them to the appropriate locations. It is surprisingly difficult to grade in a consistent manner a few papers received a week or more after the rest of the class papers have been graded, and there is a strong temptation to set such papers aside in the press of more recent work that is also waiting. It is particularly difficult at the end of the quarter when graders and faculty leave campus for vacations and trips. The approach to this problem has been to exert every effort to minimize delays as much as possible at every point in the system; logs are maintained of the dates when materials are sent to the companies, dates when work is received from the companies and sent to the instructors for grading, dates when graded work is received by SITN for resending to the companies, etc. so that sources of unnecessary delay can be identified and corrected. Graders are encouraged to expedite TVI papers by explanation of the program, obvious marking of TVI papers, and additional grader compensation for the TVI students. In some ways it might be easier if the TVI program were larger, since then the number of papers would facilitate comparative grading and perhaps justify hiring additional graders just for the TVI program, although this would create problems of equity in grading. It has been very important to frequently monitor the logs to make sure that the TVI materials do not get delayed unnecessarily.

A related problem is simply the loss or lack of recording of TVI papers and grades because of the many steps in handling and transmission. On a number of occasions grades for TVI students have initially been lower than appropriate because late papers were not recorded with a subsequent penalty in grade computation. By recording grades of returned TVI papers as they pass through the SITN office it has been possible to compare records with the instructor and make appropriate corrections. This is a somewhat delicate matter as it creates additional work for the instructor and requires complete trust of the instructor in the accuracy of the separate SITN records. Both this and the problem of grading delay mentioned above can make the TVI students require more effort by the instructor than their number might indicate.

Because the videotaping is done live with no backup tapes in order to minimize costs, it sometimes happens that a recording is faulty due to recorder malfunction. It is very important that faulty tapes not be sent to the remote companies since considerable delay and bad feeling results if the bad tape is not discovered until viewed by the TVI students. A program of spot checking all tapes before mailing has been used, although it is not possible to view all tapes completely. With a careful program of equipment maintenance this problem has occurred rarely; a staff engineer conducts a four hour weekly maintenance procedure on all videorecorders which

includes cleaning of heads and guides, degaussing, and checking of tension, tracking, braking, waveform, video and audio. In the few cases where bad tapes have occurred it has generally been possible to get a duplicate tape from one of the other TVI companies receiving the same course.

It is characteristic of both televised and TVI instruction recorded live from the classroom that the quality of instruction becomes very apparent to the viewer. A well organized, competent instructor who relates well to his class and is free of mannerisms will come across very well when viewed on the television screen; poor teaching, on the other hand, is glaringly apparent. Industrial students can be less tolerant of poor course organization or preparation than the on-campus students, as would be expected with their greater maturity. Since no faculty is uniformly excellent, it is important to be sensitive to selection of the better instructors for the TVI program. Monitoring of the TVI courses by the campus coordinator, use of evaluation questionnaires and interviews with the TVI students all aid in selecting those courses and instructors who relate best to the TVI program.

Other problems and methods used to deal with them have been discussed above. Tutor motivation, company atmosphere relative to the TVI continuing education program, development of a balanced academic program of course offerings, maintenance of student motivation, etc.; none of these problems prevent the development of a viable and successful TVI program, but they require careful and sometimes continuing attention.

V. ESTABLISHING A TVI PROGRAM

As discussed above, the Stanford TVI program grew out of and integrated with the existing Honors Cooperative Program and the Stanford Instructional Television Network which had been providing continuing education to local industry in the San Francisco Bay area for a number of years. The existence of these simplified the initiation and implementation of the TVI experimental program since for the most part existing courses, administrative procedures, and television facilities could be used with little additional change.

Now that the educational effectiveness of the TVI method has been established to the satisfaction of the Stanford faculty and administration, it is appropriate to consider a more general view of the implementation of TVI without having these prior facilities and procedural arrangements available. Substantial savings in equipment would be possible without the complete television transmission facility, and different arrangements for course administration, accreditation, and liaison may well be appropriate. In this section we briefly discuss some of these considerations when setting up a TVI program alone. Included is a summary of equipment and operating costs that have been obtained from an analysis of the experimental program operated at Stanford. More extensive cost data on the Stanford ITFS System is available in Miller and Baldwin [1].

A. STUDIO CLASSROOM AND RECORDING FACILITIES

The basic facilities required for generating videotapes for TVI is a room equipped with one or more cameras, microphones, appropriate lighting, instructor and student seating, a console for the camera operator, and one or more video recorders. The television equipment and operation should not intrude upon the classroom presentation, and both the students and instructor should feel comfortable and free to interact.

The Stanford studio classrooms have worked well, and are described in detail by Pettit and Grace [1]. Considerable effort was devoted to making them look more like classrooms than television studios. A solid-state monitor is provided for each two students. Each monitor has a microphone mounted on top of it which is actuated by a "push-to-talk" switch on the front of the monitor. A minimum of two cameras are used, one over the instructor's desk and the other at the rear of the room, both having remote operator-controlled position and zoom capability. The overhead camera is used not only for viewing information generated by the instructor as he sits facing the class working on a pad, but also for viewgraphs, slides, demonstrations, figures in books, and other materials that the instructor may bring into the class. The rear camera can view the entire classroom, show closeups of the instructor, or follow the instructor's work at the chalkboard. Appropriate lighting,

comfortable seating, and sound conditioning (drapes, carpet, quiet air conditioning if used, etc.) are also desirable. These classroom modifications cost approximately \$25,000. Control equipment and two monochrome reel-to-reel half-inch videorecorders (one for back up) cost an additional \$20,000, for a total of \$45,000. At each remote installation, a minimum of two videotape players (one for backup) and a 17" TV monitor are set up on a cart that can be rolled into any of a number of viewing rooms at the off-campus site. The complete cost of this equipment is somewhat less than \$2000.

Several additions have been made to the Stanford TV studio classrooms since the system was first installed to improve the television presentation. A third camera with pan and zoom capability was added at the front of one classroom to allow side views of the instructor, a front view of the whole class, and faces of individual students when engaged in a dialogue with the instructor. A video switching unit can provide a more interesting format by permitting split screen views of the instructor talking to a student who has asked a question, corner inserts or superposition of the instructor's face when working for an extended period of time on the pad with the overhead camera, etc. Excessive use of such techniques can be distracting and irritating to the students, but can be helpful when used with moderation.

There are several changes which could improve the television presentation but which to date have not been added to the Stanford system. One of these is the use of color, although as discussed above there is a question whether the benefits of color are worth the additional cost, equipment complexity, and operator skill required. A less obvious but more useful change would be to use improved remote control servo systems for camera position control; these should not only be quiet and free from jerkiness or overshoot, but would preferably provide proportional speed control instead of on-off motor action, making the following of the instructor's movements much smoother and more accurate. In the case of a large lecture hall where a speaker shows slides, viewgraphs or movies on a large screen, two rear cameras and directed lighting would be desirable to allow rapid switching between the speaker and the screen. A videotape editing capability would also be useful, although the Stanford system has operated with a minimum of tape editing since this can be very timeconsuming and can rapidly increase costs; the main application would be for special situations and occasional tape mishaps.

Some organizations may prefer to use videocassettes rather than reel-to-reel videotape equipment because of the greater ease in playing and lower likelihood of tape damage. The Stanford TVI program has preferred to use the reel-to-reel equipment partly because of the lower cost but primarily because with the videocassette equipment readily available there was a much longer time delay in stopping and rewinding short portions of the tape, a procedure which we felt was

essential to successful functioning of the TVI method and which should therefore be made as easy and rapid as possible. Little difficulty has been experienced with tape damage or misuse of the reel-to-reel equipment. For purposes of comparison, however, quotations are given in Table 5.1 for systems using videocassettes in both monochrome and color.

B. OPERATION AND MANAGEMENT OF A TVI PROGRAM

When setting up a program solely for TVI instead of the combined TV/TVI program operated at Stanford, considerable simplification of the management and operation arrangements should be possible, since more of the personnel and facilities at Stanford are concerned with the much larger live television program to industry than with the TVI program, although the former facilitated the initial setting up of the TVI program.

1. Operation Personnel and Costs at the Originating Organization

Needs and costs for operation and maintenance personnel would depend on the size of the program and the number and sophistication of the studio classrooms used to prepare the TVI recordings. One qualified technician/engineer could run a single classroom operation. His salary together with minor maintenance costs would cost about \$20,000 annually. A two or more studio classroom system would add about \$6000 per classroom, since the additional rooms could be staffed by student assistants.

Someone needs to function as the TVI Campus Coordinator, having the responsibility for selecting courses, making arrangements with instructors, handling and mailing of recordings, class handouts, problems and examinations, as well as processing registration, billing, and acting as liaison between the university or organization generating and distributing the TVI materials and the companies or organizations where the TVI students are located. One possible arrangement would be to have a faculty member who is interested in the program serve as the TVI Campus Coordinator with an administrative assistant or secretary to handle the daily details. The amount of time required for these functions would depend on the size of the TVI program.

An alternative assessment of program costs can be stated on a per lecture basis, as shown in Table 5.2. From this it can be seen that TVI lectures can be provided to a group of 10 students at an approximate cost of \$2.20 per student-lecture, with the costs going down considerably as the number of TVI groups using the same lecture increase. For comparison, the operating cost of "real time" television using the Stanford ITFS system is \$2.43/student-lecture. It should be noted that both the live television and the TVI operating costs are marginal costs; i.e. the cost of operating the on-campus class from which the recorded or broadcast television is obtained is not included.

Table 5.1

CAPITAL COST BREAKDOWN PER CLASSROOM FOR ON-CAMPUS ITV FACILITIES

Item	2 Camera System (Black & White)	3 Camera System (Black & White)	3 Camera System (Color)
1. MATERIALS			
Instructor's Desk	\$ 2,240	\$ 2,240	\$ 2,240
Classroom Camera System	22,950	28,000	50,000
Instructor Lighting System	1,950	1,950	2,950
Student Light Fixtures (12 each)	1,440	1,440	1,440
Classroom TV Monitors & Mounts	900	900	900
Miscellaneous: Wire, Power Panel, etc.	2,500	2,500	2,500
Subtotal	\$31,980	\$37,030	\$60,630
2. VIDEO-TAPING FACILITIES			
VCR Rack	\$ 2,200**	\$ 2,200**	\$ 2,200*
Video Cassette Recorders (3/room)	4,600	4,600	4,600
TV Monitors	690	690	1,650
Audio Amplifiers (2/room)	80	80	80
Speakers (3/room)	45	45	45
Distribution Amplifiers (1/room)	240	240	240
Wire Connectors and Hardware	250	250	250
Video Cassettes (blank)	800	800	800
Subtotal	\$ 8,905	\$ 8,905	\$ 9,865
3. MISCELLANEOUS COSTS (ONE OR TWO CLASSROOMS)			
Shipping	\$ 2,500	\$ 2,500	\$ 2,500
Travel and Per Diem	1,200	1,200	1,700
Crating and Packing	400	400	400
Subtotal	\$ 4,100	\$ 4,100	\$ 4,600
4. CONSULTING/ENGINEERING (includes)			
Project Manager	\$ 4,850	\$ 5,000	\$ 6,500
System Engineering			
Drafting			
In-Plant System Testing			
Installation Supervision and Checkout			
5. INSTALLATION LABOR (PER CLASSROOM)	<u>1,200</u>	<u>1,250</u>	<u>1,350</u>
TOTAL	\$51,035	\$56,285	\$82,945
6. TWO STUDENTS DESK (Model 8005-2) (Installed)	\$725 ea. desk	\$725 ea. desk	\$725 ea. desk

* Classroom TV Monitors not required when two student desks are installed. Delete from Item 1.

** Only one required for two classroom system.

<u>Item</u>	<u>Amortized Cost Per Lecture</u>
1. 1/2" tape @ \$16, played twice per lecture	\$ 1.00
2. Videotape players and recorders (amortized over 10 years)	3.40
3. Student operators	3.50
4. Tape mailing (preparation and round-trip postage)	5.60
5. Tutor salaries (for on-campus teaching assistant)	3.50
6. Homework grading expenses	2.00
7. Engineering and administration	1.50
8. Space amortization	<u>.50</u>
	\$ 22.00

Table 5.2 - Amortized cost per lecture of TVI facilities

2. Academic and Accreditation Arrangements

A basic decision needs to be made as to whether the TVI courses will be part of an accredited degree program. At Stanford this has been the case and it is felt that this is a strong incentive for some TVI students to participate in the program and to complete the courses in a timely fashion. It is quite true, however, that many more senior professionals are not interested in credit or a degree program and are both aware of the need for continuing education in their field and sufficiently motivated and self disciplined to complete courses and do all of the associated assignments. The arrangements with the university or organization where the TVI materials are prepared would be considerably simpler if there is no accreditation involved, if there is a sufficient number of these students to support the program. Accreditation arrangements require the support of the faculty and administration for a viable program.

3. TVI Arrangements at the Student Organization

For the most part the arrangements at the company or organization where the TVI courses are to be used will be similar those that have evolved in the Stanford TVI program as discussed above. This can vary considerably depending on the number of students, integration of the TVI courses into the continuing education program of the organization, support by management for the program, etc. Basically needed are the TVI Coordinator who provides liaison between TVI students, company management, and the source of the TVI courses. Also needed are physical facilities for holding the TVI classes, arrangements for tutors, and policy decisions as to student financial reimbursement and released time when participating in the TVI program.

VI. CONCLUSIONS AND RECOMMENDATIONS

The tutored videotape instruction technique was invented in an effort to provide the benefits of both lectures and small group discussions to off-campus graduate engineering students. Experience gained from three years of operation of the program had suggested that the TVI technique is at least as and possibly more effective than either instruction in a large lecture classroom or live TV with audio feedback. In the study reported here several studies and experiments were conducted to further evaluate this experience, to assess the influence of various factors and to determine student attitudes toward TVI.

A. Conclusions from this Study

In order to carry out statistical analyses of the TVI student performance, a study was made of the correlations between available prior academic and examination records and TVI class showings. A regression analysis showed that graduate record examination scores had little predictive value. A better indicator was a factor derived from the undergraduate grade point average of the student with a correction factor obtained from previous performance of students from the same institution in graduate work at Stanford. An attempt to statistically compare TVI and on-campus Stanford students having a similar background and study program showed no significant difference although TVI seemed at least as good as classroom instruction. The power of this study was low because of low sample size.

Several experiments were conducted with TVI groups on campus to evaluate the TVI technique in a manner which would accommodate differences in backgrounds and working conditions between the campus and the industrial students. Here it was found that TVI seemed significantly more effective than large live class instruction for students of lower ability. The importance of the way in which the tutor worked with the TVI group was evident, particularly in student attitudes toward the TVI method; it was found that a good tutor not only had a good grasp of the subject matter and a sensitivity to difficult points in the material being presented but also was able to set the mode of the TVI group and to encourage interaction. It was clearly shown that the TVI students felt more free to ask questions and after having had a good TVI experience would prefer this mode of instruction to a large lecture classroom situation.

In the final on-campus experiment it was again shown that TVI is at least as good as a large class and probably better for students of lower ability. For this experiment an observation instrument was developed to facilitate studies of group interaction. Students who experienced the interaction of the TVI group strongly preferred this mode to that of a class watching television without stopping or discussion. It was seen that in the higher ability TVI group there

was a positive correlation between interaction and performance. The nature of TVI group interaction differed considerably for groups selected on the basis of ability; lower ability students used the discussion to clarify and improve understanding of the material presented while higher ability students augmented the presentation with related questions and extensions to class-presented material.

A survey of off-campus TVI students revealed considerable influence of the management attitude and arrangements for conducting the TVI classes. The educational climate seemed best where the students did not feel time pressure to finish the TVI class, where management was supportive of continuing education, and where tutors felt that their efforts were recognized by management.

Despite our efforts to utilize careful statistical procedures during the course of this study, small sample sizes and wide variations in student backgrounds and programs have not permitted a rigorous test of the conclusion that TVI is more effective than TV or classroom teaching although we have obtained no data which suggests that it is not. We are also unable to generalize to subject areas other than engineering and science, though we believe that the general principles of the TVI format will apply to a wide range of subjects and audiences. Our experience in this study as well as in the continuing TVI program still seems to support the contention that TVI has the following principle advantages over both in-class and live television instruction:

1. It is (or can be) educationally more effective than either classroom or televised instruction, especially for the student with marginal qualifications, primarily because it permits students to ask more questions and, through organized discussion, find more answers for themselves than they could in either of the other formats.
2. It is cheaper than either classroom or televised instruction from the point of view of marginal costs. This is because it requires neither new educational plant nor expensive broadcast facilities.
3. It makes good use of teaching resources by using faculty for course preparation and paraprofessional tutors for discussion of the lectures. For this latter function it draws on the substantial (if latent) interest in tutoring that exists in a large segment of the population.
4. It allows instruction to take place at the convenience of the students. It is not bound by either the academic calendar or a broadcast schedule.

These advantages are substantial, and there is little in the TVI program at Stanford that could not also be utilized in similar programs elsewhere.

B. RECOMMENDATIONS

In order to assist others who may wish to initiate similar or modified TVI programs, a number of comments may be made based on the Stanford experience.

1. Factors that Contribute to the Effectiveness of TVI

We feel that the following factors are important for the educational effectiveness of TVI:

- a. Tutor attitude, personality and instructional style are very important. The tutor should be willing and interested in helping the students in his group. He should attend all or nearly all of the TVI sessions. Tutor competence is important, but it is better that he not be so overqualified that he becomes bored or impatient with student lack of understanding. Compensation of tutor effort is important for a continuing program.
- b. Group size is also important. Fewer than two or three students does not lead to good interaction and tends to make the method expensive, while group size greater than 8-10 tends to inhibit discussion and reduce the frequency with which the recording is stopped. A group size of 3-8 seems optimum, although this can vary with student personalities and acquaintance with each other.
- c. Depending on the maturity of the student, commitment to a degree program or similar educational objective may be important in sustaining interest and motivation. Certainly for most students completion of graded problems and examinations results in a more productive educational experience.
- d. Active classroom participation in the live class is desirable. For the subjects and audiences served to date, unrehearsed, unedited video recordings of classroom lectures may be used and, in addition to being far less costly, may have more "presence" and be more interesting to watch than tightly scripted, professionally produced classes. Even if the students ask no questions their presence stimulates most instructors to create a better presentation than if lecturing solely to a camera in a studio.
- e. It is important that the instructor be well-organized, knowledgeable in the subject, and free of annoying mannerisms. The charisma of a good instructor is emphasized on the video recording.

- f. For industrial students, management attitudes toward participation play a very important role in the success of a continuing program. Job pressures which create long hours and interfere with family life markedly increase the difficulty of pursuing an educational program.
- g. Continued management and evaluation of a TVI program needs to be the concern and principal responsibility of a person designated to coordinate and provide liaison between the academic institution and the TVI students. Many details require timely attention that would otherwise not be given by either the instructor or the company.

None of the factors impose unmanageable requirements, but they are all important. With attention to group size, good tutoring, quality of recorded educational material, adequate handling of supplementary materials and grading of problems and examinations, the TVI method can provide an excellent educational experience and opportunities for needed education in otherwise difficult or impossible situations.

2. Extensions of the TVI Method

While the Stanford experience with the TVI method has been in the area of graduate instruction in science and engineering, we believe the method can also be successfully extended to other subject areas and audiences. Such extension will undoubtedly bring special problems of their own, but the probability and rewards of success seems high enough to warrant the effort of trying.

An obvious extension is to use the TVI method to reach a larger audience than has been served to date in the Stanford program. This will involve the recruiting and training of many tutors, organizing and supporting large numbers of local tutorial groups, reproducing and distributing the video recordings and homework, arranging for the grading of homework and examinations, and so on. Our experience cannot offer much insight into how these problems can best be solved. However, the need for a separate administrative structure is apparent, since the grading alone could not be readily integrated into the daily operation of an existing educational program.

With regard to large scale distribution it is natural to consider the use of a satellite communications system for the transmission of lecture material and homework, and for telephone-based conferences between tutors or students and faculty. For the delivery of lectures videorecorders could be installed at the separate sites to tape the lectures as they are received. Use of non-prime time and slow scan techniques could reduce the cost of such transmission. It might also be advantageous for the on-site tutor to watch the lecture as it is being recorded and to call the instructor to discuss problems before the recording is shown to the TVI group.

A cautionary note should be added, however. Intriguing as the use of satellites might be, in the TVI program they are basically replacing either the mail service or a closed circuit TV broadcast system that is operated in precisely the same way as the satellite system would be. Hence, there is a question of what the most cost-effective method of delivery TVI might be. There is also a question concerning the area over which it is advisable to distribute TVI groups. In particular, if a course requires regular face-to-face contact between tutors, faculty members and coordinators, a maximum travel distance of perhaps 500 miles is possibly indicated. In these cases the use of a satellite, which offers coverage over much larger distances, may actually encourage the distribution of TVI groups over a larger area than is desirable.

Another issue that may need resolution relates to transfer of credit for TVI-provided courses between originating institutions as more such institutions develop appropriate recorded lecture material. It seems clear that there will be a demand for the best instructors and courses as more of this type of instruction becomes available, and that these will not necessarily all originate at the same institution. Rather, it may be necessary to develop a clearinghouse and accreditation standards so that TVI students can select from a wider and better set of courses from a variety of institutions and still apply this work toward a degree program.

A final development that needs early attention is the evaluation of the application of the newly emerging videodisk and/or videofilm technology rather than videotape for TVI classes, since there seem to be a number of significant advantages to be gained. Among these advantages appear to be lower cost of recordings and playback equipment, less chance for damage to the recording by unskilled users, the ability to rapidly scan forward or backward without losing picture synchronization, the ability to view a single frame for an extended period without damage to the recording, random access to selected frames, more compact and lighter recordings that are less costly to mail and to store, easy and rapid duplication, etc. Since playback units will only achieve low cost when design becomes frozen and production runs become large, evaluation of this technology for educational applications should be explored in the near future while designs are still flexible and standards have not yet precluded modification.

REFERENCES

1. J. M. Pettit and D. J. Grace, "The Stanford Instructional Television Network," IEEE SPECTRUM, May 1970.
2. W. R. Kincheloe, "A Comparison of Educational Effectiveness," NSF Workshop on Continuing Education for Engineers at Midcareer, Dallas, TX, August 1974.
3. W. R. Kincheloe, "Educational Effectiveness of Videotape for Off-Campus Instruction at Stanford University," ASEE Annual Conference, Colorado State University, June 1975.
4. James F. Gibbons, "Tutored Videotape Instruction," position paper prepared for National Institute of Education, July 1976.
5. Godwin C. Chu and Wilbur Schramm, "Learning from Television: What the Research Says," Educational Resources Information Center (ERIC) Report No. ED-014900, Stanford University, Stanford, CA 94305.
6. R. M. Anderson, Jr., Engineering Coordinator for Continuing Education, Purdue University, West Lafayette, Md., personal communication.
7. David C. Miller and Lionel V. Baldwin, "Use of Television for Presentation," in TEACHING AIDS IN THE COLLEGE CLASSROOM, L. P. Grayson and J. M. Biedenback, Eds., American Society for Engineering Education, 1975.
8. James F. Gibbons, Quarterly Progress Report No. 1, Contract NIE 400-75-0038, 10/25/75.
9. James F. Gibbons, Quarterly Progress Report No. 2, Contract NIE 400-75-0038, 12/10/75.
10. James F. Gibbons, Quarterly Progress Report No. 3, Contract NIE 400-75-0038, 6/10/76.

Appendix A

OBSERVATION INSTRUMENT MANUAL (EES201B - Winter 1976)

The instrument was designed to determine the amount, kind, and casual effects of interaction occurring in tutored-video-tape (TVI) groups. This is accomplished by recording questions, responses, and actions categorized in five ways: "WHO does the action, etc?", "TO WHOM is it done?", "WHAT is done?", and "WHEN is it done?". Interaction coding forms are used.

The WHO category specifies which person initiates the question, response, or action and the recipient is designated by the TO WHOM category. The WHAT category is used to designate the kinds of questions, responses, and actions. The HOW category describes the affective nature of the WHAT code; a response made in a critical manner, such as, "This is the last time I will explain it!", would be coded negative or very negative under the HOW category. In determining "HOW" categories verbal and nonverbal cues should be used. The TIME blank on the coding forms is for the time the question, response, or action is initiated.

It is important that each comment, interchange of ideas, and question, etc. be coded on the coding forms. In otherwords, each time something is done or said something should be recorded. If it is not clear how to code a particular interaction, details should be written on the back of the coding form describing the interaction in terms of the five categories.

OBSERVATION CATEGORIES

CATEGORY	CODE VOCABULARY
WHO and TO WHOM	
Instructor	I
Class - instructor's class	C
Tutor	T
Group - tutor's group	G
Student on tape (in class)	S
Student in TVT group	P1, P2, etc

WHAT

Question	
Mathematical	QM
How to apply in the real world	QA
How it functions (operates)	QF
Request	R
Other	QO

Action

Start the tape	GO
Stop the tape	S
Back up tape	BT
Use blackboard	BB

Response

Expand	E
Clarify	C
Integrate	I
Other	O

HOW

Very positive	VP
Positive	P
Negative	N
Very negative	VN

WHEN

Quick (short time)	Q
Time action begins and ends	:
is entered, unless quick time	:
then time action begins is entered	
and Q is circled.	

D.8 - Definition of WHAT codes

Interactions can range from a sequence of short questions, actions, and responses (a few seconds or less) to one question-response that lasts several minutes. A sequence lasting only a few seconds is coded by marking in the WHAT category on one row the order the responses, etc occur. The time the sequence begins and ends is entered in the TIME category. One long question-response is coded alone on one row and the time the question-response begins and ends is entered in the TIME category. If the duration of an interaction is only a few seconds then Q is circled in the TIME category and the time the interaction begins is also entered.

Questions

Mathematical questions (QI) pertain to any mathematical manipulation or derivation. Questions concerned with how the material under discussion can be applied in real world situations are designated as QA. Examples are, "Could you give an example using linear programming?" or "Are Markov processes used by decision makers?" Usually QA would refer to making an abstract concept more concrete. Questions concerned with how something functions or operates is designated as QF, such as, "What happens to the collector current when resistor R3 is increased?" Questions that can't be categorized by one of these codes is designated as QO. Note that a question on the mathematical formalization of an application of the theory is coded as QA. Questions may be initiated by instructor (I), tutor (T), in-class students (S), or TVT students (Pi).

Requests (R) are information seeking questions that are not concerned directly with the content of the subject matter. Examples of requests are, "Does anyone know the answer to that question?", "Are there any questions?", and "Do you understand where this equation comes from?" Requests are usually used to determine the students' state of knowledge. Requests may be initiated by instructor (I), tutor (T), in-class students (S), or TVT students (Pi).

Actions

Action codes designate the tutor starting and stopping the tape, backing up the tape to review, and using the blackboard. In the TIME category only time action is initiated is needed for start the tape (GO), stop the tape (S), and back up the tape (BT). Time action begins and ends is needed for use of blackboard (BB). The WHO category will always be the tutor and there is no TO WHOM category. When the action begins an interaction sequence of short questions and responses it can be coded on the same row as the questions and responses. Similarly, if the action ends an interaction sequence. Examples below will clarify.

Response

Responses are usually answers to questions but they can also refer to unsolicited explanatory comments by the tutor or students; the tutor can stop the tape and make comments on the material without being asked to do so. However, usually, the tutor will first ask if the students understand the material.

Expand (E) refers to "expanding" on already taught concepts by using new material. Examples are deriving an equation by a different method or going through a new example similar to an old example. Examples of Key points and phrases to look for are:

"I will SHOW you the trick he used in proving...."
You could also look at in ANOTHER WAY"
"ANOTHER author derives it by using..."
"He LEFT OUT several important points, such as..."
"I will illustrate by ANOTHER example"

Clarify (C) refers to going over the same material again. For example, if the instructor presents an example and the tutor goes over the example again in the TVT group this would be coded as clarification. Examples of key points and phrases are:

"Do you REMEMBER why the eigenvalue is zero?...."
IT IS BECAUSE....."
"REMEMBER THAT...."
"Is this CLEAR?.....(tutor's comments)..."
"Let me CLARIFY..."

Many responses (from tutor and students) will be clarification. Any time the tutor asks "Is this clear?" the response will most likely be clarification. However expansion and integration are often used for clarification purposes. In such cases they should be coded as expansion or integration. Often when the tutor asks if a point is clear a sequence of clarification, expansion, and integration responses will be made by both tutor and students.

Integrate (I) refers to relating already taught concepts. For example, the tutor may show the relationship between two transistor models or two mathematical derivations presented by the instructor. Examples of key points and phrases are:

"How does this RELATE to what he said YESTERDAY?"
This elicits an integration response
"This is what he was doing BEFORE only a different way"
"He is using the SAME trick in this derivation as BEFORE"
"YESTERDAY he said...and NOW he is saying...."

Tutor and TVT students are the only permissible codes for the WHO category for expand, clarify, and integrate. Instructor, for example, is not permissible since we are only interested in analyzing TVT interaction and not the instructor's presentation.

Examples of Interactions

Code each of the following interactions for practice.

Case 1		Time begin hrs:min:sec	Time end hrs:min:sec
Tutor:	"Is everything clear?....I see some blank looking faces"	9:10:11	9:10:18
	"Do you understand where he got this equation?"	9:10:20	9:10:24
P2:	"Isn't it from the theorem we proved yesterday?"	9:10:30	9:10:35
Tutor:	Stops the tape	9:10:50	
	"How about that, is that right?"	9:10:50	9:10:55
	"It is from the theorem proved yesterday and if you remember from last quarter it is almost identical to....."	9:11:05	9:14:00
	Starts tape	9:14:00	
Case 2		Time begin hrs:min:sec	Time end hrs:min:sec
P4:	"How does he get that?"	10:10:10	10:10:12
Tutor:	Stops tape		
	"Do you understand how he factored out the term on the left?"	10:10:20	10:10:30
	Goes to blackboard and shows how to factor out term.	10:10:50	10:15:07
	"Are there any other questions?"	10:15:30	10:15:40
	Starts tape	10:15:50	
Case 3		Time begin hrs:min:sec	Time end hrs:min:sec
P5:	"Has real data ever been fit to that model?"	9:45:11	9:45:15
Tutor	"This model is too simplified to work but more complex models have been used. An example is....."	9:45:18	9:45:35

INTERACTION CODING FORM

TIME Start	WHO			TO WHOM			WHAT			HOW	TIME End
							?	Act	Resp		
:	T	P1	P6	T	P1	P6	M	GO	E	VP	:
	I	P2	P7	G	P2	P7	A	SP	C	P	
		P3	P8	I	P3	P8	F	BT	I	N	
	S	P4		C	P4		R	BB	O	VN	
		P5		S	P5		D				
:	T	P1	P6	T	P1	P6	M	GO	E	VP	:
	I	P2	P7	G	P2	P7	A	SP	C	P	
		P3	P8	I	P3	P8	F	BT	I	N	
	S	P4		C	P4		R	BB	O	VN	
		P5		S	P5		D				
:	T	P1	P6	T	P1	P6	M	GO	E	VP	:
	I	P2	P7	G	P2	P7	A	SP	C	P	
		P3	P8	I	P3	P8	F	BT	I	N	
	S	P4		C	P4		R	BB	O	VN	
		P5		S	P5		D				
:	T	P1	P6	T	P1	P6	M	GO	E	VP	:
	I	P2	P7	G	P2	P7	A	SP	C	P	
		P3	P8	I	P3	P8	F	BT	I	N	
	S	P4		C	P4		R	BB	O	VN	
		P5		S	P5		D				
:	T	P1	P6	T	P1	P6	M	GO	E	VP	:
	I	P2	P7	G	P2	P7	A	SP	C	P	
		P3	P8	I	P3	P8	F	BT	I	N	
	S	P4		C	P4		R	BB	O	VN	
		P5		S	P5		D				
:	T	P1	P6	T	P1	P6	M	GO	E	VP	:
	I	P2	P7	G	P2	P7	A	SP	C	P	
		P3	P8	I	P3	P8	F	BT	I	N	
	S	P4		C	P4		R	BB	O	VN	
		P5		S	P5		D				
:	T	P1	P6	T	P1	P6	M	GO	E	VP	:
	I	P2	P7	G	P2	P7	A	SP	C	P	
		P3	P8	I	P3	P8	F	BT	I	N	
	S	P4		C	P4		R	BB	O	VN	
		P5		S	P5		D				
:	T	P1	P6	T	P1	P6	M	GO	E	VP	:
	I	P2	P7	G	P2	P7	A	SP	C	P	
		P3	P8	I	P3	P8	F	BT	I	N	
	S	P4		C	P4		R	BB	O	VN	
		P5		S	P5		D				
:	T	P1	P6	T	P1	P6	M	GO	E	VP	:
	I	P2	P7	G	P2	P7	A	SP	C	P	
		P3	P8	I	P3	P8	F	BT	I	N	
	S	P4		C	P4		R	BB	O	VN	
		P5		S	P5		D				

TPQ						
TPR				8.5	1.3	
				(7.3)	(5.8)	
TGQ			2.1	2.7	5.6	
			(0.3)	(2.1)	(5.5)	
TGR				6.8	2.7	
				(5.0)	(4.5)	
PTQ	16.9		5.5			
	(15.2)		(4.0)			
PTR	2.5	3.7	7.2			
	(1.9)	(7.4)	(2.8)	(6.4)		2.3
	TPQ	TPR	TGQ	TGR	PTQ	PTR

Code

- T - Tutor
- P - TVI pupil
- Q - Question
- R - Response
- G - TVI group

Fig. C.4a - Interaction data for EES201B: Percentage of time two step interactions occur. High TVI group shown in parentheses. The TPR-PTQ cell represents the tutor making a response to a pupil followed by a pupil asking the tutor a question.

Type of Question	Low TVI			High TVI			Low	High
	TG	TP	PT	TG	TP	PT	TVI	TVI
Mathematical	41	15	125	9	3	149	208	176
Applied	2	0	24	0	0	4	28	4
Function	0	0	3	0	0	9	3	0
Remark	66	9	18	66	22	21	106	115
Other	9	1	2	5	2	3	15	32
<u>Type of Action</u>								
Start the tape	96			61			97	63
Stop the tape	102			58			105	115
Back up tape	9			4			9	4
Use blackboard	20			28			21	29
<u>Type of Response</u>								
Expansion	19	5	3	2	2	0	28	24
Clarification	122	125	60	96	128	69	350	335
Integrate	3	0	0	2	1	0	3	3
Other	82	14	20	73	81	114	129	323

(b) Number of times selected one step interactions occurred in six sessions. The TG-remark cell represents the tutor making a remark to the group.

(c) Number of times questions, actions, and responses occurred in six sessions.

	WHO		TO WHOM	
	Low TVI	High TVI	Low TVI	High TVI
TVI Student	272	426	164	244
Tutor	743	644	261	384
Tape Prof.	36	15	30	20
Tape student	31	20	30	14
TVI group			510	395
Tape class			8	1

(d) Number of questions and responses made.

Number of questions and responses directed to.

Fig. C.4 (cont.) - Interaction data for EES201B.